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PRESIDENTIAL ADDRESS ON "SOME ASPECTS OF MODERN PHYSICS."

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As retiring President of the Royal Society of South Africa it is my privilege to address you to-night, and I therefore propose to deal with one or two aspects of modern physics.

It may be said that physics in its most general aspect is a discussion of the properties of matter and energy, and, since matter is now held to be electrical in origin, we may say of electricity and energy. It was usual at one time to restrict physics to the discussion of the general properties of matter and to consider those properties which depended on the different kinds of matter to be the province of chemistry. The advances of science have shown that it is impossible to draw a line between physics and chemistry. They are really different aspects of the same subject. Biology, when it tries to explain living reactions, deals with the still more complicated properties of matter and energy associated with life.

Every science is influenced by the progress made by the physicist in explaining the observed phenomena, and by the experimental methods adopted for their elucidation. One has only to look at the influence of modern physics on chemistry, astronomy, engineering, biology, etc. to see how fundamental are the advances which are being made in modern physical research.

Experimental research in physics has never experienced such a stormy period, nor has its significance for human culture ever been so generally acknowledged as nowadays. Wireless waves, electrons, X-rays, radioactive phenomena, more or less arouse everybody's interest.

Relativity.

The theory of relativity caught the popular imagination by the very reason of its abstruse nature inasmuch as it seemed to strike at the root of some of our most solidly founded notions. There is no doubt that the theory of relativity makes far-reaching claims on abstract physics. This popular interest has led to the publication of an enormous number of treatises on relativity, from the advanced publication suitable for the specialist down to the non-mathematical and often erroneous popular handbook.

It is with regret that we have to record the recent death of one of the pioneers in this subject, the distinguished Dutch physicist, Professor H. A. Lorentz of Leyden. Lorentz discovered the principle of the relativity of time, and introduced it into electrodynamics. His chief work, however, lay in his researches on the electron theory. For many years Lorentz naturally and by general consent took the leading part in every European conference of physicists.

It was left to Albert Einstein to boldly proclaim the principle of relativity as a universal postulate, and to Hermann Minkowski to set it forth in mathematical form. In 1915 Einstein by an extraordinarily brilliant piece of mathematical analysis was led to formulate a law of gravitation, which to the first order gave results identical with that of Newton, and also satisfactorily explained discrepancies which had not been accounted for. Einstein's theory also predicted other phenomena, such as the bending of light and displacements in the solar spectrum, predictions which have been verified experimentally.

Quantum Theory.

One of the outstanding features of theoretical physics of the present century is undoubtedly the rise of the quantum theory. This theory in its rapid and successful development has found its way into practically every branch of physics, substituting difference laws for differential laws.

The quantum theory came into life in December 1900, when Dr. Max Planck, Professor of Theoretical Physics at Berlin University, enunciated a method of deriving the law of black body radiation. If we keep strictly to physics and not touch on the other things which transcend physics, such as life, mind, and consciousness, there appear to be three entities: positive electricity, negative electricity, and radiation. It is by radiation that we know of the existence of most bodies. The existence of the heavenly bodies are known through their radiations of heat and light, which differ only in wave-length.

The process of radiation has always been regarded as a continuous pro-

cess and on the basis of classical mechanics certain "laws" of radiation can be deduced. Such laws were deduced by Lord Rayleigh, Jeans, and others, but exact practical measurements showed that such laws were applicable only to special cases and were not true generally. For example, the relation between the energy radiated and the temperature of the radiating body is well established and can be used for the measurement of temperature of radiating bodies. No general law had, however, been established.

Professor Planck, in his account of the origin of the quantum theory, tells how he spent years of consistently planned work seeking through the laws of electrodynamics for the goal of a general law of radiation. He came to the conclusion after years of brilliant work that an essential link to the complete understanding of the problem was missing, and decided to attack the problem through the principles of thermodynamics, with which he was more familiar. He was finally compelled in order to retain agreement between theory and experiment to take a bold step, which led away from the general wave theory, and to postulate his hypothesis of energy quanta.

According to Planck, energy of any frequency whatsoever can be emitted or absorbed only in quantities which are proportional to the frequency of the radiation, viz.:

$$e = h\nu,$$

where e is the energy radiated, ν the frequency of the radiation, and h a constant, now called Planck's constant, or quantum of action. This constant has been determined experimentally in several ways. Its value is $6{\cdot}55 \times 10^{-27}$ erg. sec.

This theory does upset the usual notions of the wave theory, according to which energy is radiated continuously in space. The explanation appears to be that classical mechanics gives a satisfactory method of treatment for matter in bulk, but needs amendment in specialised regions. The discontinuity of radiation is associated with the discontinuity of electricity in atomic structure. There can be no doubt about the success of the theory in advancing our knowledge of many physical phenomena, such as optical spectra, X-rays, photoelectric and photochemical effects, atomic heats, gamma radiations, etc.

Structure of Matter.

It is generally accepted that the material universe is composed of atoms, and that the atoms are built up of negative and positive electricity, the units being called electrons and protons. The difference between the chemical elements lies in the number and arrangement of these units in the atom.

The discovery by Sir J. J. Thomson in 1897 of the individual existence

of negatively charged particles of small mass called electrons, and that the electron was a component of the atom of matter independent of the kind of matter, was an event of extraordinary significance to science. It has been known from very ancient times that there are two kinds of electricity, which we now call positive and negative electricity, but this demonstration by Sir J. J. Thomson was the first proof of the atomic nature of electricity. Sir J. J. Thomson had already proved, as early as 1881, that an electrically charged body in motion behaved as if it had an additional electric mass due to its motion. The moving charge generates a magnetic field in the space surrounding it, resulting in an increase of energy of the moving system, which is equivalent to the effect produced by an increase of mass of the body.

This fundamental unit of electricity makes its appearance in many physical phenomena, *e.g.* as cathode rays in electric discharges, as beta rays in radioactive changes, thermions in the wireless valve, etc. Experiment shows that the ratio of the charge to the mass at slow speeds is $1{\cdot}77 \times 10^{7}$ electromagnetic units and that the charge is $1{\cdot}59 \times 10^{-20}$ electromagnetic units, hence the mass is $9{\cdot}0 \times 10^{-28}$ grm. The mass of the hydrogen atom is $1{\cdot}66 \times 10^{-24}$ grm., hence the mass of the electron is 1845 times less than that of the hydrogen atom. The variation of mass with speed agrees with the rate of variation computed on the assumption that the mass is all of electrical origin. No advantage is gained by assuming any other type of mass. The mass of the electron, if purely electrical, can be accounted for by supposing the negative charge distributed over a spherical surface of radius of the order of 10^{-13} cm. The mass of the atom must be due to the resultant of the electrical masses of the charges which make up its structure.

One of the difficulties in the attack on the problem of the structure of matter or atomic structure was the uncertainty as to the nature of positive electricity. No experiment has yet succeeded in discovering a positive charge with a mass less than the mass of the hydrogen atom with a charge equal and opposite to that of the electron. The greater mass of the proton, as the unit of positive electricity is called, is to be explained by supposing that the distribution of electricity is much more concentrated for the proton than for the electron. X-ray analysis of crystal structure shows that the radii of atoms in crystals lie between 10^{-8} cm. and 10^{-7} cm. If atoms are built up of electrons of radii 10^{-13} cm. and of protons of smaller dimensions, it is evident that the atom must be of very open structure.

Radioactivity.

The study of the spontaneous radiations of radioactive substances has thrown much light on this difficult problem of the structure of the atom.

The characteristic feature of radioactivity is that it occurs essentially only in the case of elements of greatest atomic weight, Uranium and Thorium. These elements are to be regarded as being so heavily loaded with matter that they are unstable and disintegrate spontaneously. The radiations from these substances were found to be of three kinds, which were called alpha (α), beta (β), gamma (γ) radiations. The α radiations are positively charged particles with two units of charge and a mass four times that of the proton. The β radiations are swift-moving electrons, and the γ radiations are radiations of very short wave-lengths like X-rays.

The chemical laws of radioactive change were enunciated by Soddy and Fajans. The statement in its briefest form asserts that a radioactive element when it loses an α particle goes back two places in the periodic table, and when it loses a β particle it goes forward one place. This law is a consequence of a much wider generalisation discovered by Moseley in 1913.

There can be no doubt that the expulsion of a single α particle lowers the charge of the atom by two units and the mass by four units, while the expulsion of a β particle raises the charge by one unit. This is clearly shown from the disintegration series of Uranium and of Thorium in the following table.

Uranium Series.				Thorium Series.			
Substance.	Radiation.	Atomic number.	Atomic weight.	Substance.	Radiation.	Atomic number.	Atomic weight.
Ur I	α	92	238	Th	α	90	232
Ur X_1	β	90	234	$Mesoth_1$	β	88	228
Ur X_2	β	91	234	$Mesoth_2$	β	89	228
Ur II	α	92	234	Radioth	α	90	228
Ionium	α	90	230	Th X	α	88	224
Radium	α	88	226	Th Em	α	86	220
Radon	α	86	222	Th A	α	84	216
Rad A	α	84	218	Th B	β	82	212
Rad B	β	82	214	Th C	α β	83	212
Rad C	α β	83	214	Pb		82	208
Rad D	β	82	210				
Rad E	β	83	210				
Rad F	α	84	210				
Pb		82	206				

Soddy suggested that lead derived from minerals containing uranium but no thorium might have a smaller atomic weight than that of ordinary lead, while that derived from thorium minerals might have a greater atomic

weight. The atomic weight of ordinary lead is 207·19. The experiments of Richards and Honigschmid gave the values 207·77 and 207·90 for lead from Ceylon thorite; 206·08 and 206·04 for uranium lead from Norwegian clevite and crystallised pitch blend from Morogora.

It is now easy to understand the appearance in the radioactive series of isotopes, *i.e.* elements of the same nuclear charge but different atomic weight. The existence of these isotopes was first brought to light by a study of the radioactive elements.

Alpha Ray Scattering.

The α particles from radioactive substances are projectiles with the most concentrated energy known to science. An α particle is liberated with a velocity of about ten thousand miles per second, and has so much energy that it produces a visible flash on striking a zinc sulphide crystal. Its velocity is twenty thousand times that of a swift rifle bullet, and, mass for mass, its kinetic energy is four hundred million times greater.

Sir W. H. Bragg investigated the stopping power of gases on α particles. Bragg's experiments and Wilson's photographs of α ray tracks in gases showed that α particles may shoot in straight lines through from three to seven centimetres of air before they are brought to rest. An α particle would, in travelling through seven centimetres of air, penetrate about half a million molecules. We conclude that an atom has so loose a structure that another atom, if endowed with sufficient speed, can shoot straight through it without doing anything more than shaking off in some instances an electron or two. Sir Ernest Rutherford now investigated the problem of passing bundles of α rays through thin foils of metal. The action of the foils on the rays was investigated by allowing the rays after they passed through the foils to fall on a zinc sulphide screen which scintillated by the impact of the rays on the screen. The bundle of rays undergoes general scattering which is distributed about a mean position of greatest probability according to the laws of chance. But there are occasional large departures from the incident direction which cannot be accounted for in the ordinary way. An alpha particle being between seven and eight thousand times more massive than an electron would no more be deflected by an electron in the atom than a cannon ball would be deflected by a pea.

Rutherford traced the effect to very intense electric fields that start out from very small elements of space. These experiments led Rutherford to postulate the nuclear atom, *i.e.* an atom consisting of a nuclear positive charge surrounded by electrons. Van der Brock arrived at the same idea of a nuclear atom from chemical evidence. Rutherford showed that the magnitude of the nuclear charges that must be assumed to explain these

deflections was approximately equal to half the atomic weight. Barkla had also shown that the number of electrons necessary to explain X-ray scattering was approximately half the atomic weight. Moseley's classical experiments on the wave-lengths of X-rays generated from different elements showed that there was in the atom a fundamental quantity which increased by regular steps as we pass from one element to the next in the periodic table. Reviewing the evidence he came to the following conclusion, "that the nuclear charge is the same as the number of the place occupied by the element in the periodic system." The place in the periodic system he called the *atomic number* of the element.

Subsequent experiments by Rutherford and Chadwick have shown that the nuclear charges necessary to explain the scattering of α rays by platinum, silver, and copper are 77·4, 46·3, and 29·3, while the atomic numbers are 78, 47, and 29. The agreement is sufficient if we consider the difficulty of the experiments. Schonland has found the scattering of β rays by aluminium, copper, silver, and gold to be in agreement with the above theory.

Moseley's law that the nuclear charge of an atom is equal to its atomic number, *i.e.* its place in the periodic system, is now universally accepted. This law immediately explains the empirical rule of radioactivity. An α ray carries away two positive charges and therefore the atom goes back two places in the table, while on the other hand if it emits a β particle it moves forward one place in the table.

We have reached the important conclusion that the atoms of matter consist of a massive nucleus carrying a positive charge surrounded by electrons at distances which are great compared with the diameter of the electron and of the nucleus. The nucleus contains the positive charge and hence the mass. The mass and radioactive properties are associated with the nucleus, the X-ray spectra, the optical spectra, and the chemical properties are associated with the planetary electrons.

The Rutherford-Bohr Atom.

On closer inspection, however, the Rutherford atom is incapable of fulfilling a necessary condition of an atomic model, namely, the emission of definite spectral lines characteristic of the atom.

On ordinary mechanics the motion of a charged electron rotating in a closed orbit is continually accelerated towards the centre, and hence the electron would be continually emitting radiation, *i.e.* continuously losing energy. Its orbit must therefore decrease until finally the electron would fall into the nucleus. On ordinary mechanics the number of the orbits is unlimited. The velocity in any orbit can be altered to make the centripetal force balance the nuclear attraction.

It was in 1913 that Dr. Neils Bohr discarded ordinary mechanics and substituted Planck's quantum theory of radiation, that energy is radiated not continuously, but in multiples of the quantum unit. The orbits are determined in accordance with quantum principles, only certain orbits being possible. The orbits are to be regarded as stationary states in the sense that the electron does not radiate in a quantum orbit. An electron in passing from one orbit to another radiates energy of a definite period equal to the difference between the energies of the two orbits. This extension of the Rutherford atom has had very far-reaching effects on modern physics.

The hydrogen atom with one nuclear charge and one electron is the simplest atom, and naturally the first application of the theory was to test the agreement between the predicted and experimental optical spectra of hydrogen. It is easy to calculate the frequencies of the radiations according to the theory. They are in excellent agreement with the experimental values. There are three series: one in the ultra-violet called the Lyman series, one in the visible spectrum called the Balmer series, and one in the infra-red called the Paschen series. Electrons passing from the second, third, fourth, etc. orbits to the first orbit give rise to the Lyman series; electrons passing from the third, fourth, fifth, etc. to the second give rise to the Balmer series; while electrons passing from the fourth, fifth, sixth, etc. to the third give rise to the Paschen series. Only twelve lines of the Balmer series are ordinarily observed in laboratory vacuum discharges. The radius of the orbit necessary to give the twelfth line is about $0{\cdot}8 \times 10^{-6}$ cm. The ordinary hydrogen atom has a radius about $0{\cdot}5 \times 10^{-8}$ cm. The distance between the molecules of hydrogen gas would be about $0{\cdot}8 \times 10^{-6}$ cm. under a pressure of 7 mm. of mercury. To obtain experimentally more of these lines the pressure would have to be reduced below this value, and accordingly the number of molecules in the tube would be insufficient to give intensities necessary for observation. Professor R. W. Wood has, however, succeeded in carrying the observations in the laboratory as far as the twentieth line, while thirty-three lines have been observed in certain stellar spectra, and twenty-nine in the spectrum of the solar chromosphere.

In 1897 Pickering observed a series of lines in certain stellar spectra which could be represented by an equation similar to that of hydrogen. These lines were accordingly ascribed to hydrogen. Bohr showed that according to the new theory they should be due to ionised helium, *i.e.* to an atom with two nuclear charges with one planetary electron. That they were not observed in the laboratory was supposed to be due to the high degree of ionisation required. Fowler, however, by passing strong electric currents through a mixture of hydrogen and helium, observed as many as 188 of these lines. It has now been proved conclusively that they are due

to helium and not to hydrogen. Evans and Paschen have observed them in tubes in which no trace of hydrogen could be obtained.

A remarkable extension of Bohr's theory was made by Sommerfeld, who assumed elliptic orbits instead of circular orbits. These orbits led to the same result as to the number and position of the spectral lines, but indicated a greater number of possible orbits, and hence the chances of passing from one orbit to another are increased. The possibility of emission of any particular line is increased.

The utility of Sommerfeld's extension became apparent when he introduced the relativity correction for the mass of the electron. Sommerfeld has shown that the result of this correction is that the electron describes a steadily advancing ellipse and gives rise to slightly different lines lying close together. It is well known that lines which appear as single lines in an instrument of moderate resolving power may show complicated structures when examined by an instrument of high resolving power.

Sommerfeld's brilliant theory has been confirmed experimentally by Paschen for helium. Michelson in America, Fabry in Paris, Merton and Nicholson at Oxford, M'Lennan and his co-workers at Toronto have verified it in the case of hydrogen.

X-ray spectra can also be explained on the Bohr theory. X-ray radiations have a wave-length of the order of 10^{-8} cm., while optical radiations have a wave-length of the order of 10^{-5} cm. The X-rays have their origin in the inner orbits, while optical spectra have their origin in the outer orbits. To produce characteristic X-ray radiation the bombarding electrons must have an energy sufficient to penetrate into the innermost orbit and ionise the atom by the expulsion of an electron. On account of the intensity of the electric field near the nucleus, the X-ray spectra are much simpler, and certain rules can be formulated with regard to them. The application of these rules to optical spectra has helped in correlating theory and experiment. While space quantisation and selection rules which have been adopted unquestionably represent something very real, as is shown by the experimental agreement with theory, the physical interpretation leads to many difficulties. The experiments of Wood, Millikan and Bowen, M'Lennan, Fowler, and others, have shown that the agreement between the experimental spectra and the spectra predicted from the theory is almost beyond what could have been expected. The quantum theory of the Rutherford-Bohr atom has resulted in an insight into the physics of the atom which seems almost incredible, and has turned spectroscopy from a heterogeneous collection of miscellaneous facts into a rapidly advancing science.

These ideas suitably grafted on to the older ideas of physics have been able to coordinate vast stores of facts, yet they do not appear to be suffi-

ciently wide to embrace all that is required in atomic physics. One difficulty is that light appears to behave as a wave when travelling through a telescope and in refraction or dispersion phenomena, but behaves as a projectile when it is engaged in emission or absorption, or photoelectric action. There is, however, another fundamental difficulty. According to Bohr's theory the spectra should be governed by various kinds of quantum numbers which should take the values 1, 2, 3, etc. Experiment shows that these numbers are not sufficient, that half-integral numbers insist on turning up. Millikan showed that in addition to the relativistic cause of doublet separation explained by Sommerfeld there must be a non-relativistic cause. To explain this, as well as the anomalous Zeeman effect, Uhlenbach and Goudsmit introduced the idea of a spinning electron. It is necessary, however, to restrict the spinning in certain ways, and to assign one half the fundamental unit of angular momentum to each electron, some spinning in one direction, others in the opposite direction. Consideration of these difficulties has led atomic physicists to look for some departure from the point of view of Bohr, Sommerfeld, and their followers.

From a principle of dynamics laid down by Hamilton more than a hundred years ago it can be shown that the motion of a particle in a field of force can be represented as a ray of a propagated wave surface. All classical dynamics is built up of the motion of particles, which can be equally well regarded as wave motions with the energy travelling along certain rays, the paths of the particles. A wave theory of the motion of electrons in atoms has been developed by L. de Broglie on these lines within the last few years. The electron is regarded as a train of waves whose group velocity is the velocity of the electron. De Broglie makes the suggestion that just as the corpuscular theory of light breaks down when the obstacles and apertures become comparable with the wave-length, so the particle theory of dynamics breaks down when the distances concerned are of atomic dimensions. The reason is the same in each case, the dimensions concerned become comparable with the wave-length.

A wave theory of mechanics which coincides with Hamilton's theory on the large scale and is true down to atomic dimensions has been developed by Schroedinger.

The following claims are made for the new mechanics :—

(*a*) The laws of motion and the quantum conditions are deduced simultaneously from a principle of Hamilton.

(*b*) A definite localisation of the electric charge in space and time can be associated with the wave system ; and with the aid of ordinary electrodynamics accounts for the frequencies, the intensities, and the polarisation of the emitted light and makes superfluous all sorts of selection and correspondence principles.

(*c*) It seems possible to pursue in detail the so-called transitions which have been mysterious.

(*d*) Where there is disagreement between the old and new theories, experimental evidence seems to be in favour of the new.

There are, however, one or two difficulties in the way of the new wave mechanics. One of them is that in its present form, it offers no explanation of the atomicity of matter and electricity. We may therefore expect the next few years to show interesting developments.

Mass of the Nucleus.

If a strong electric discharge is sent through a tube containing the atoms of an element, the atoms may be ionised by the removal of an electron. That electron may attain a high velocity under the influence of the electric field constituting a cathode ray or beta ray. The remainder of the atom will have a positive charge and will move in the opposite direction, constituting the positive ray. If the vacuum is high these positive rays, although more sluggish than the electrons because of their greater mass, may attain high velocities and be deflected on passing through strong electric and magnetic fields.

Sir J. J. Thomson introduced this method of positive ray analysis. The deflections produced depend on the ratio of the charge to the mass. We know that the charges are integer multiples of the electric unit and hence from the deflections we are able to compare the masses of the positive ions. Sir J. J. Thomson discovered in this way that the gas neon consisted of two elementary constituents of masses 20 and 22 relative to oxygen 16. These two constituents are isotopes.

This method of mass analysis has been greatly extended by Aston. He found that with the exception of hydrogen, the nuclear masses can be represented by whole numbers, oxygen being taken as 16. After this demonstration there was no logical difficulty in regarding protons and electrons as the bricks out of which atoms have been constructed. Since the radioactive substances give off α and β particles from the nucleus, we regard the nucleus as being built up of protons and electrons, the protons being in excess. An atom of atomic weight m is converted into one of atomic weight $m+1$ by the addition of an electron plus a proton. If both enter the nucleus the new element is an isotope of the old one for the whole nuclear charge remains the same, but its atomic weight has been changed. If, on the other hand, the proton enters the nucleus and the electron remains outside an element of higher atomic number will be formed. If both are possible they will represent elements of the same atomic weight with different chemical properties. Such elements are known, *e.g.* the principal constituents of

calcium and argon. Such elements are called isobars, The case of hydrogen is unique. Its atom consists of one proton as nucleus with one planetary electron. It is the only nucleus which is not composed of protons and electrons packed together, and its mass is not represented by a whole number on the oxygen scale.

If the additive law of mass were true for the nucleus built up of protons and electrons, then the masses of all atoms would be whole numbers on the scale H=1. Measurements with the mass spectrograph show that this is not true. The reason for the failure of the additive law is that inside the nucleus the protons and electrons are so closely packed together that their electromagnetic fields interfere and a certain fraction of the combined mass is destroyed, whereas outside the nucleus the distances between the charges are too great for this to happen. The mass destroyed corresponds to the energy released. The greater this is the more tightly are the component charges bound together and the more stable is the nucleus which is formed. The present evidence indicates that the proton and electron are the fundamental constituents of the nucleus, but it is very probable that secondary combining units play an important part. For example, the expulsion of helium nuclei from radioactive bodies indicates that the helium nucleus of mass 4 is a secondary unit in atom building. We should anticipate that the whole number rule discovered by Aston would hold only to a first approximation since the mass of the proton must to some extent depend on the detailed structure of the nucleus.

For this reason measurements of the nuclear mass are of fundamental importance in arriving at a knowledge of the structure of the nucleus. Aston constructed a mass spectrograph with five times the resolving power of the old one, sufficient to separate the mass lines of the heaviest known element with an accuracy of 1 in 10,000. He has shown that some of the elements consist of a large number of isotopes, *e.g.* Sn has eleven, Xe has nine, Hg has six, and so on. Also he finds the whole number rule an approximation. He has determined the deviation from the whole number for a large number of elements.

A numerical estimate of the stability of the helium nucleus can be obtained from the mass defect if we take account of Einstein's relation between mass and energy. If 4 grm. of hydrogen were converted into helium the energy liberated would give over a million horse-power for an hour.

The stability of the helium nucleus is evident from the experiments of Rutherford on the disintegration of elements by bombardment of α particles. It has been found impossible to knock protons out of elements of atomic mass $4n$, such as carbon (12), oxygen (16), and sulphur (32). It is reasonable to assume that α particles form units in the nucleus and that these units form stable combinations among themselves. To disintegrate a single helium

nucleus would require more than three times the kinetic energy of the swiftest α particle. There is little likelihood at present of the helium nucleus being dissociated since the α particle is by far the most concentrated source of energy at our disposal.

Rutherford has attacked the problem of the nucleus from the data available from radioactive elements. The experiments of Ellis, Skinner, and Fraulein Meitner on gamma radiations have shown that there are energy levels inside the nucleus just as there are X-ray levels and optical levels outside the nucleus. Rutherford puts forward the view that the heavy atom has well-defined regions in its structure. At the centre is the controlling charged nucleus of very small dimensions surrounded at a distance by a number of neutral satellites describing quantum orbits controlled by the central field from the nucleus due to polarisation. The central nucleus is a compact structure of radius not greater than 10^{-12} cm. The region round the central nucleus extending to about $1{\cdot}5 \times 10^{-12}$ is probably occupied by electrons and possibly charged nuclei of small mass. The electrons in this region circulate round the nucleus with a velocity close to that of light. The comparatively large region from 1·5 to about 6×10^{-12} may be occupied by neutral satellites kept in equilibrium by the polarising action of the electric field. In the case of radioactive substances the satellites consist in part of neutral helium nuclei, which lose their closely bound electrons when the electric field falls beyond a certain critical value, and may be ejected as α particles. The two electrons which are liberated from the satellite fall in towards the nucleus, probably revolving with nearly the speed of light close to the central nucleus. Occasionally one of the electrons is hurled from the system, giving rise to a disintegration electron or beta particle. The disturbance of the neutral satellite system by the liberation of an α particle may lead to a rearrangement involving the transition of one or more satellites from one quantum orbit to another, emitting in the process gamma rays of frequencies determined by quantum relations.

The only way towards the solution of this difficult problem is to go on experimenting, trying to coordinate theory with experiment, which is the final court of appeal.

I think it is agreed that the last thirty years are the most wonderful in the history of physics. The next thirty promise to be quite as interesting.

NOTE ON $(n-1)$-BY-n ARRAYS WHOSE PRIMARY MINORS HAVE A COMMON FACTOR.

By Sir THOMAS MUIR, F.R.S.

1. If our title should suggest to the reader any particular array as fulfilling the required conditions, it will in all probability be one of the type

$$\begin{array}{cccc} 1 & a & a^2 & a^3 \\ 1 & b & b^2 & b^3 \\ 1 & c & c^2 & c^3 \end{array}$$

each of whose 3-line minors is well known to have the factor

$$(c-b)\,(c-a)\,(b-a) \quad \text{or} \quad |\, a^0b^1c^2 \,| ,$$

the cofactors being

$$1, \quad \sum a, \quad \sum ab, \quad abc,$$

a result which may be conveniently written

$$\left\| \begin{array}{cccc} 1 & a & a^2 & a^3 \\ 1 & b & b^2 & b^3 \\ 1 & c & c^2 & c^3 \end{array} \right\| = \left| \begin{array}{ccc} 1 & a & a^2 \\ 1 & b & b^2 \\ 1 & c & c^2 \end{array} \right| . \left(1, \ \sum a, \ \sum ab, \ abc\right).$$

It is certainly the *oldest* instance of an array possessing the property in question, having been known, in substance if not in form, to Cauchy in 1812.

2. A similar example of much later date (Hist., iv, p. 62) is

$$\left\| \begin{array}{cccc} a & h & g & af+2gh \\ h & b & f & bg+2hf \\ g & f & c & ch+2fg \end{array} \right\| = \left| \begin{array}{ccc} a & h & g \\ h & b & f \\ g & f & c \end{array} \right| . (1, \ h, \ -g, f).$$

In both of them the common factor of the four minors is itself one of the four, and this suggests to us the obtaining of the general theorem :

In order that

$$\left\| \begin{array}{cccc} a_1 & a_2 & a_3 & \mathrm{P} \\ b_1 & b_2 & b_3 & \mathrm{Q} \\ c_1 & c_2 & c_3 & \mathrm{R} \end{array} \right\|$$

may be equal to

$$|\, a_1b_2c_3 \,| \, . \, (1, \ \mu_1, \ \mu_2, \ \mu_3)$$

we must take

$$\begin{aligned} P &= (a_1,\ a_2,\ a_3)\,(\mu_1,\ \mu_2,\ \mu_3) \\ Q &= (b_1,\ b_2,\ b_3)\,(\quad \cdot\cdot \quad) \\ R &= (c_1,\ c_2,\ c_3)\,(\quad \cdot\cdot \quad). \end{aligned}$$

In other words, *the primary minors of the array*

$$\left\Vert \begin{matrix} a_1 & a_2 & a_3 & \mu_3a_1-\mu_2a_2+\mu_1a_3 \\ b_1 & b_2 & b_3 & \mu_3b_1-\mu_2b_2+\mu_1b_3 \\ c_1 & c_2 & c_3 & \mu_3c_1-\mu_2c_2+\mu_1c_3 \end{matrix} \right\Vert$$

have the factor $|\,a_1b_2c_3\,|$ *in common, the cofactors being*

$$1,\ \mu_1,\ \mu_2,\ \mu_3.$$

Of course we have here taken $n=4$ merely for convenience in writing.

3. Other two specially interesting examples illustrating the theorem are :

$$\left\Vert \begin{matrix} l & 1 & x & yz-x^2 \\ m & 1 & y & zx-y^2 \\ n & 1 & z & xy-z^2 \end{matrix} \right\Vert = \left| \begin{matrix} l & 1 & x \\ m & 1 & y \\ n & 1 & z \end{matrix} \right| \cdot \left(1,\ -\sum x,\ \sum xy,\ 0\right),$$

and

$$\left\Vert \begin{matrix} x+y & 1-xy & \cdot & x+y \\ -2 & x+y & x-y & 2xy \\ x-y & \cdot & 1+xy & y-x \end{matrix} \right\Vert$$

$$=2(x^2+1)\,(y^2+1)\,.\,\{1,\ y-x,\ -x-y,\ xy\}.$$

4. It is immediately evident as a deduction that, by annexing an arbitrary additional row, we obtain a 4-line determinant having the related 3-line minor as a factor, and that by suitable choice of the said row the deduced determinant may become of extra importance ; for example,

$$\left| \begin{matrix} a & h & g & af+2gh \\ h & b & f & bg+2hf \\ g & f & c & ch+2fg \\ af-gh & bg-hf & ch-fg & abc-fgh \end{matrix} \right| = \left| \begin{matrix} a & h & g \\ h & b & f \\ g & f & c \end{matrix} \right|^2.$$

5. Cases in which the common factor is not a primary minor of the array seem to be less readily obtainable, but to be more attractive when found. Let us begin with one where the law of formation is simple, and where the related determinant is not a deduction but historically came first.* For $n=5$ it is

$$\left\Vert \begin{matrix} a & x & b & c & d \\ a & b & x & c & d \\ a & b & c & x & d \\ a & b & c & d & x \end{matrix} \right\Vert = X\,.\,\{a,\ -a,\ a,\ -a,\ x+b+c+d\}$$

---

* *Vide* Hist., iii, p. 480.

where $$X=(x-b)(x-c)(x-d).$$

Putting $d=0$, the case for $n=4$ follows, namely,

$$\left\|\begin{matrix} a & x & b & c \\ a & b & x & c \\ a & b & c & x \end{matrix}\right\| = (x-b)(x-c) \,.\, \{a, \ -a, \ a, \ x+b+c\}.$$

6. In the next type the square array left on deleting the first column is zero-axial skew, and the common factor is a pfaffian. For example,

$$\left\|\begin{matrix} -a_2 & . & b_3 & b_4 \\ -a_3 & -b_3 & . & c_4 \\ -a_4 & -b_4 & -c_4 & . \end{matrix}\right\| = \left|\begin{matrix} a_2 & a_3 & a_4 \\ & b_3 & b_4 \\ & & c_4 \end{matrix}\right| . (-b_3, \ -b_4, \ -c_4, \ 0),$$

and

$$\left\|\begin{matrix} -a_2 & . & b_3 & b_4 & b_5 \\ -a_3 & -b_3 & . & c_4 & c_5 \\ -a_4 & -b_4 & -c_4 & . & d_5 \\ -a_5 & -b_5 & -c_5 & -d_5 & . \end{matrix}\right\| = \left|\begin{matrix} b_3 & b_4 & b_5 \\ & c_4 & c_5 \\ & & d_5 \end{matrix}\right| . (\mathrm{A}, \ \mathrm{B}, \ \mathrm{C}, \ \mathrm{D}, \ \mathrm{E})$$

where

$$\mathrm{A} = \left|\begin{matrix} a_2 & a_3 & a_4 \\ & b_3 & b_4 \\ & & c_4 \end{matrix}\right|, \ \mathrm{B} = \left|\begin{matrix} a_2 & a_3 & a_5 \\ & b_3 & b_5 \\ & & c_5 \end{matrix}\right|, \ . \ . \ . \ . \ , \ \mathrm{E} = \left|\begin{matrix} b_3 & b_4 & b_5 \\ & c_4 & c_5 \\ & & d_5 \end{matrix}\right|.$$

The theorem deducible therefrom is Cayley's regarding a bordered zero-axial skew determinant.

7. The third example * differs from the two preceding in that it is known only to hold for the case where n is 5. It is

$$\left\|\begin{matrix} 1 & 1 & 1 & 1 & 1 \\ a & b & c & d & e \\ c+d & d+e & e+a & a+b & b+c \\ eab & abc & bcd & cde & dea \end{matrix}\right\|$$

$$=\mathrm{Y}(b-c, \ -a+b, \ e-a, \ -d+e, \ c-d)$$

where
$$\mathrm{Y}=\overset{\circ}{\sum} ab(c^2-e^2)$$
$$=ab(c^2-e^2)+bc(d^2-a^2)+cd(e^2-b^2)+ \ . \ . \ . \ . \ .$$

The deduced 5-line determinant (Hist., iv, p. 475) is equal to

$$\mathrm{Y} \,.\, \overset{\circ}{\sum} \frac{a(c-d)}{b+e-a}.$$

* This I have already briefly mentioned in the American Math. Monthly, xxxi. (1924), p. 273.

8. The fourth example, which holds only in the case where n is 4, is connected with Lagrange's like-producing quadrinomial, and in the plan of its construction is perhaps the most curious of all. It is

$$\left\| \begin{matrix} -\phi x_2 & \phi x_1 & -ax_4 & ax_3 \\ -\chi x_3 & bx_4 & \chi x_1 & -bx_2 \\ -\psi x_4 & -cx_3 & cx_2 & \psi x_1 \end{matrix} \right\| = \mathrm{Z}(-x_4,\ x_3,\ -x_2,\ x_1),$$

where

$$\mathrm{Z} = \phi\chi\psi x_1^2 + \phi bcx_2^2 + \chi cax_3^2 + \psi abx_4^2.$$

An interesting special case of the related determinant is

$$\begin{vmatrix} \phi\chi\psi x_1 & \phi bcx_2 & \chi cax_3 & \psi abx_4 \\ -\phi x_2 & \phi x_1 & -ax_4 & ax_3 \\ -\chi x_3 & bx_4 & \chi x_1 & -bx_2 \\ -\psi x_4 & -cx_3 & cx_2 & \psi x_1 \end{vmatrix} = \mathrm{Z}^2.$$

9. The law of formation of the preceding array is more easily followed when the x's are separated from their coefficients, thus—

$$\begin{matrix} \phi & \phi & -a & a \\ \chi & b & \chi & -b \\ \psi & -c & c & \psi, \end{matrix} \qquad \begin{matrix} -x_2 & x_1 & -x_4 & x_3 \\ -x_3 & x_4 & x_1 & -x_2 \\ -x_4 & -x_3 & x_2 & x_1, \end{matrix}$$

and the construction plans of the two resulting arrays are studied each by itself. The help thus got, however, is not all our reward; for, strange to say, each of the said new arrays is exactly of the type which we have under consideration, and is thus an unexpected addition to our material. A short examination shows that the primary minors of the first are each divisible by

$$\begin{vmatrix} \phi & -a & a \\ b & \chi & -b \\ -c & c & \psi \end{vmatrix} \quad i.e. \quad \phi\chi\psi + \phi bc + \chi ca + \psi ab,$$

the cofactors being

$$1,\ -1,\ 1,\ 1;$$

in other words, that *its primary minors differ at most only in sign*: also, that the primary minors of the second are each divisible by

$$x_1^2 + x_2^2 + x_3^2 + x_4^2,$$

the quotients obtained being

$$-x_4,\ x_3,\ -x_2,\ x_1.$$

Further, although the derived determinants associated with these new arrays may be easily got from that of § 8 by first putting ϕ, χ, ψ, a, b, c

each equal to 1 and then putting each x equal to 1, it is not superfluous to note that the second specialisation of the two is

$$\begin{vmatrix} x_1 & x_2 & x_3 & x_4 \\ -x_2 & x_1 & -x_4 & x_3 \\ -x_3 & x_4 & x_1 & -x_2 \\ -x_4 & -x_3 & x_2 & x_1 \end{vmatrix} = (x_1^2+x_2^2+x_3^2+x_4^2)^2,$$

a result of Souillart's dating back to 1860 (Hist., ii, pp. 287-288).

RONDEBOSCH, S.A.,
22nd February 1928.

A NEW METHOD OF AERIAL SURVEYING: NOTE ON THE DETERMINATION OF THE VERTICALS OF A PLATE PAIR.

By H. G. Fourcade.

(With one Text-figure.)

In the solution, given in the author's first paper on " A New Method of Aerial Surveying " (*Trans. Roy. Soc. of S.A.*, vol. 14, pt. 1, 1926, p. 101), for the determination of the inclination i of the aerial base of a plate pair, and the rotation θ round that base that will make the XY plane of reference vertical, a necessary step was left out. The distances, corresponding to PA and PB of fig. 1 of the present note, are not the same as the similarly lettered polar distances of previous figures and have to be computed first.

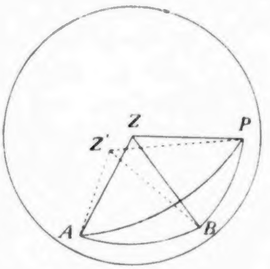

Fig. 1.

The sphere in fig. 1 is centred at C, which is one of the three ground control points A, B, C. CZ' is the parallel, through C, to the z-axis of the air co-ordinates, and CP the parallel to their x-axis, which is the direction of the base. Z is the zenith at C, ZA and ZB are the angles that the chords CA and CB make with CZ, and $Z'A$, $Z'B$ the corresponding values given by the air co-ordinates. $PZ'B$ and $PZ'A$ being the angles of direction of CB and CA given by the air co-ordinates are known, and AB is supplied by the ground survey. Since $Z'P=\frac{\pi}{2}$, we have first

$$\begin{aligned}
\tan Z'PB &= \sin PZ'B \tan Z'B. \\
\cos BP &= \cos PZ'B \sin Z'B. \\
\tan Z'PA &= \sin PZ'A \tan Z'A. \\
\cos PA &= \cos PZ'A \sin Z'A, \\
Z'PB - Z'PA &= APB.
\end{aligned}$$

The solution can now proceed as before:

$$\begin{aligned}
\sin PBA &= \sin PA \sin APB \operatorname{cosec} AB, \\
PBZ &= PBA - ZBA, \\
\cos PZ &= \cos BZ \cos BP + \sin BZ \sin BP \cos PBZ, \\
\sin (\lambda+\theta) &= \sin BZ \sin PBZ \operatorname{cosec} PZ,
\end{aligned}$$

where $\theta = ZPZ'$, $\lambda = Z'PB$, and $i = \frac{\pi}{2} - PZ$.

The zenith distances ZA, ZB, corrected for curvature, are given by

$$ZA = \cot^{-1}\frac{h_a - h_c}{b} + \frac{b}{2R},$$

and

$$ZB = \cot^{-1}\frac{h_b - h_c}{a} + \frac{a}{2R},$$

where b and a are the lengths of the sides CA and CB of the control triangle, h_a, h_b, h_c, the heights of the control points A, B, C, and R is the radius of the earth. AB and ZBA are given, as data of the ground survey, by

$$\cos AB = \cos ZA \cos ZB + \sin ZA \sin ZB \operatorname{cosec} AB$$

and

$$\sin ZBA = \sin AZB \sin ZA \operatorname{cosec} AB.$$

The vertical determined is that of C. At any other point D it is given by

$$\theta + \frac{s}{R}\sin \alpha \quad \text{and} \quad i + \frac{s}{R}\cos \alpha,$$

where s is the horizontal distance of D from C, α, the angle of direction of CD on the air system, and R, the radius of the earth. When D is the middle point of the aerial base the level surface of the area mapped from the base may, as was shown in a former paper (*Trans. Roy. Soc. of S.A.*, vol. 14, p. 69), be further treated, without sensible error, as being plane.

Capt. M. Hotine, R.E., who pointed out the omission that is now rectified, communicates a much simpler solution, which, although approximate, will be sufficiently accurate in all ordinary cases.

Let $v_1 = ZA - Z'A$ and $v_2 = ZB - Z'B$, in which, as above, ZA, ZB are the zenith distances of A and B, corrected for curvature, and $Z'A$, $Z'B$ the corresponding values derived from the air co-ordinates. Let also α, β be the angles of direction of CA and CB given by the air co-ordinates. Then, θ and i, being small, are determined by

$$\theta \sin \alpha + i \cos \alpha = v_1,$$
$$\theta \sin \beta + i \cos \beta = v_2.$$

In fig. 1 of the author's paper on "The Principal Point and Principal Distance" (*Trans. Roy. Soc. of S.A.*, vol. 16, pt. 1, 1928) α should be, as in the text, the angle A_1OC', and β the angle B_1OC'.

Witte Els Bosch,
March 1928.

THE ESSENTIAL OIL OF *AGATHOSMA MICROPHYLLA*.

By JAMES LEONARD BRIERLY SMITH and KENNETH ALLAN CALDWELL ELLIOTT.

Chief among the herbal remedies employed by the natives of South Africa are the various plants designated as "Buchu." These plants, which vary in size from small shrubs to fair-sized trees, appear to grow only where there is an abundant rainfall, and are thus confined almost exclusively to the coastal belt and to mountainous regions.

The better known varieties are of the *Barosma Group*, *B. etulina* or "mountain buchu" being the variety in chief use for medicinal purposes.

Agathosma microphylla or "Stembok buchu" is a short, stunted shrub which grows in patches on the seaward side of the coastal hills, being found fairly extensively about Knysna and in the neighbouring districts. The shrub gives off a strong aniseed-like odour which is very noticeable in the still valleys where it flourishes.

The leaves of the plant are very small, seldom exceeding 4 mm. in length and 1 mm. in breadth; they are well provided with oil glands.

It is remarkable that the oil-content of the dried leaves appears to vary with the season; the air-dried leaf collected in summer contains from 2·0 to 3·0 per cent. of volatile oil, while samples gathered in winter contain as much as 5 per cent.

The present investigation was performed with 45 pounds of air-dried leaves collected at various times.

By distillation in steam, this amount yielded 795 grm. of a clear yellow oil having a powerful odour, in which that of myrcene and of aniseed could be distinguished.

The oil is laevorotatory and has

$$\alpha_D^{20} = -12' \, 10'', \quad D^{20} = 0{\cdot}920; \quad n_D^{20} = 1{\cdot}499.$$

The chief constituent is methyl chavicol,* which appears to form approximately 50 per cent. of the oil.

The terpene-hydrocarbon content does not exceed 3 per cent., and is probably myrcene.

* $MeO{\cdot}C_6H_4-CH_2-CH{=}CH_2$ (*p*).

The remaining constituents appear to be alcohols of formula $C_{10}H_{18}O$, being in part *l*-Linalool, esters 4 per cent., while Eugenol occurs to the extent of about 1 per cent.

Experimental.

Six hundred grm. of the crude oil were fractionated at the ordinary pressure (720 mm.), using a short column, and were found to distil as follows :—

Temperature °C.	Percentage distilling.	Odour.
180–190	0·5	Of myrcene.
190–195	7·5	,, linalool.
195–200	10·0	,, ,,
200–205	16·0	,, ,,
205–210	16·0	,, ,,
210–215	16·0	Of aniseed.
215–220	12·0	,, ,,
220–225	6·0	,, ,,
225–230	3·0	Acrid.
230–250	4·5	Empyreumatic.
Residue and loss	8·5	Gummy, with acrid odour.

Careful and repeated refractionation resulted in the following :—

Temperature °C.	Per cent. distilling.	a_D^{20}.	D^{20}.	n_D^{20}.	Odour.
163–173	3·0	..	0·820	1·468	Of myrcene.
173–192	2·0	..	..	..	Sharp.
192–198	12·0	−17′ 10″	0·878	1·478	Of linalool.
198–207	27·0	−13′ 40″	0·904	1·480	,,
207–215	36·0	..	0·945	1·508	Aniseed.
215–225	5·0	..	0·960	1·519	,,
225–235	2·0	..	0·980	..	Pungent.
235–260	2·0	..	..	..	Empyreumatic.
Residue	8·0	..	..	..	Gummy, with unpleasant odour.

The crude oil (4·6 grm.) was boiled with potassium-permanganate solution; the odour of anisic aldehyde became apparent immediately. After removal of precipitated manganese dioxide, addition of excess hydrochloric acid to the resulting alkaline solution produced a copious precipitate

(2·0 grm.) of a white solid. This was separated, dried, and recrystallised from benzene, and proved to be *Anisic Acid*: melted at 182° C., mixed melt with anisic acid, 182° C. The silver salt was prepared and analysed.

Found	Ag=42·0 per cent.,
$C_8H_7O_3Ag$ requires	Ag=41·7 ,,

This result indicated the presence of at least 45 per cent. of $C_{10}H_{12}O$ in the oil.

A Zeisel estimation on the crude oil gave the following results :—

Found	–OMe= 9·6 per cent.,
$C_{10}H_{12}O$ requires	–OMe=20·9 ,,

This confirms the presence of at least 45 per cent. $C_{10}H_{12}O$ in the crude oil.

The fraction of the oil boiling at 207–215° C. evidently consisted chiefly of methyl chavicol. On heating some of this fraction in a sealed tube with 5 per cent. of dry sodium ethoxide at 210° for fifty hours, it was found to have been changed almost quantitatively to anethole: the major part of the resulting oil boiled at 225–230° and on cooling solidified, and then melted at 20°.

The crude oil (50 c.c.) was extracted with caustic-soda solution. The aqueous solution was freed from oil, and rendered acid. The dried ethereal extract on evaporation left an oil (0·45 grm.) with a pungent clove-like odour, which proved on investigation to consist chiefly of Eugenol.

The crude oil had an ester value of 11·0, and, after acetylation, of 130. This corresponds with 4 per cent. of esters reckoned as $C_{10}H_{17}O$ Ac., and about 30 per cent. of alcohols.

The fractions boiling at 192–198° and 198–208° appeared to consist chiefly of alcohols. In spite of repeated fractionation at the ordinary pressure and *in vacuo*, these fractions split up in exactly the same fashion.

The fraction boiling at 192–198° proved still to contain about 15 per cent. of methyl chavicol. It yielded anisic acid on oxidation, and a Zeisel estimation gave

	–OMe= 3·2 per cent.
$C_{10}H_{12}O$ requires	–OMe=20·9 ,,
Whence $C_{10}H_{12}O$ in this fraction	=15 ,,

This fraction was saponified with alcoholic potash and proved to contain practically no esters. Reduction with sodium and alcohol also had no apparent effect on it, and it could not be induced to yield any oxime or semicarbazone.

Titration with bromine in carbon-tetrachloride solution indicated a molecular weight of about 150 with two ethylenic linkages in the molecule.

Molecular weight estimation gave M=(1) 152, (2) 160. $C_{10}H_{18}O$ requires M=154.

Combustion Analysis.

Found (1) C=78·60. H=10·90.
(2) C=78·61. H=10·90.

A mixture of 20 per cent. $C_{10}H_{12}O$ and 80 per cent. $C_{10}H_{18}O$ requires
C=78·60, H=10·90.

The odour of this fraction and its physical constants pointed to the presence of *l*-linalool.

On oxidation with chromic acid, this fraction yielded an oil with a powerful odour, which gave a chief fraction over 222–225 at 712 mm., and which appeared to be chiefly citral.

The fraction boiling at 198–208° appeared to be of the same type as that boiling at 192–198°. After saponification of esters with alcoholic potash, it gave practically the same results on combustion analysis.

Found C=78·70, H=10·90.
Also found —OMe=3·8 per cent.
$C_{10}H_{12}O$ requires 20·9 ,,
Whence $C_{10}H_{12}O$ in this fraction=about 20 per cent.

It yielded anisic acid on oxidation with permanganate, and citral on oxidation with chromic acid.

It is thus indicated that the portion of the oil boiling between 190° and 208°, and comprising about 40 per cent. of the whole, is at least 75 per cent. alcohols of formula $C_{10}H_{18}O$, consisting in part of *l*-linalool.

The crude oil (30 c.c.) was extracted with concentrated sodium-salicylate solution. This was freed from adhering oil and steam distilled. The oily distillate after separation and drying (5 grm.) proved to be practically identical with the fraction boiling at 192–198°. It boiled at 195–199° (718 mm.) and its density D^{20}=0·880 (linalool has D^{20}=0·877).

The small fraction boiling at 163–173° had a powerful odour resembling that of myrcene. Owing to the small quantity available it was not found practicable to isolate pure myrcene. The results obtained indicate that it is myrcene contaminated with some of the alcohols of higher boiling-point.

Found C=86·7 per cent., H=11·50 per cent.
D^{14}=0·820, n_D^{20}=1·468.
Myrcene requires C=88·20 ,, H=11·80 ,,
D^{20}=0·802, n_D^{20}=1·468.

The oil also possibly contains some anethole: especially in the higher fractions the odour of anisic aldehyde appeared immediately when these were treated with potassium-permanganate solution in the cold. Repeated fractionation to eliminate lower boiling material yielded the fraction boiling at 225–235° at 720 mm., having $D^{20}=0{\cdot}985$. This on oxidation yielded anisic acid, but this fraction could not be induced to crystallise even when seeded with some solid anethole.

Owing to the relatively small amount of material available, the presence of anethole could not be definitely established.

The essential oil of *Agathosma microphylla* is thus made up of the following:—

	Per cent.
Terpene hydrocarbon: probably myrcene . . .	3
Alcohols: $C_{10}H_{18}O$, in part probably *l*-linalool . .	30
Phenols: eugenol	1
Phenol ethers: methyl chavicol and possibly anethole .	50
Esters: possibly $C_{10}H_{17}OCOCH_3$	4
Residue, sesquiterpenes, loss, etc.	12

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DEPARTMENT OF CHEMISTRY,
RHODES UNIVERSITY COLLEGE,
GRAHAMSTOWN, SOUTH AFRICA,
September 1926.

CURTISIA FAGINEA AIT. ("ASSEGAAI"): AN ECOLOGICAL NOTE.

By John F. V. Phillips, D.Sc. (Edin.),
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Curtisia faginea Ait., the "Assegaai," * is a tree of sylvicultural importance in the Knysna forests. As the producer of the finest spokewood in the country it is justly famed. With the object of casting a little light upon its general ecology in relation to its sylviculture, the writer for some years has studied the species in the Knysna forests. The aim of the present communication is to outline the more important features yielded by this study.

Distribution.

1. *General.*—"Assegaai" ranges from the Cape Peninsula through the relict forest patches in the districts of Swellendam and Riversdale to the forests of the George-Knysna-Zitzikamma region, is sparingly represented in the Zuurberg mountain patches (Schonland, 1919, p. 81), but is not known to occur in the large coastal forests at Alexandria. It is found in the forest of the Katberg, Pirie, and Amatola mountains. In the Transkeian forests it is very rare on the coast, frequent but poorly grown in the forests of the plateaux, but is more abundant and better developed in the mountain forests at 3500–5000 feet (Miller, 1925, MSS.). It is present in the forests of Natal and Zululand. Swynnerton (1912, p. 3) records the plant from forest patches near Melsetter (7000 feet) in Gazaland; in these it is said to be one of the most important and most abundant trees. According to Eyles (in a letter, 1927), the only other records for Southern Rhodesia are Teague, No. 211, Odzani Valley, Umtali (about 3500 feet), and Eyles, No. 2575 (per J. S. Henkel), Inyanga (6000–7000 feet). It occurs in the forests of the Transvaal. Wangerin, in his monograph of the Cornaceae, gives no records from Tropical Africa.

Of the 115 species of Cornaceae, *Curtisia* is only one in the section *Curtisioideae* (distinguished by its possession of a *ventral* raphe). The

* The wood was not, and is not, used for making assegaais.

only other African genera of the Cornaceae are *Melanophyllum* (3 spp., Madagascar), *Cornus* (1 sp., Equitorial E. Africa), and *Kaliphora* (1 sp., Madagascar). *Curtisia* is thus well isolated, having no very close relatives.

The geological range of the plant is quite unknown, but it is of interest to record that foliage simulating that of *Curtisia* has been recorded by Phillips (1927, p. 195) in beds of late Tertiary age, at Knysna.

2. *At Knysna.*—" Assegaai " is fairly well represented in the *climax* forests, as is shown by the following percentage-distribution figures (all stems of all tree and large shrubby species from 1 inch diameter upward): Gouna forest (medium-moist and dry types), 4·6 per cent.; Deepwalls (medium-moist and moist types), 6·1 per cent.; Kaffirkop (medium-moist and dry types), 5·2 per cent.; Harkerville (medium-moist and moist types), 3·24 per cent.; Blaauwkrantz (medium-moist and dry types), 6·6 per cent.; Lottering (medium-moist and dry types), 3·5 per cent.; Storms River (medium-moist and moist types), 7·5 per cent.

General Description.

Dimensions.—Adult " Assegaai " attain heights from 50 to 70 feet, with clean boles from 25 to 40 feet; the girths range from 4 to 6 feet (exceptionally individuals of 8 to 9 feet are found).

Bole.—Usually cylindrical, not deeply fissured, and not buttressed; usually at a slight angle.

Bark.—In younger trees, a light grey or cinnamon; in older individuals, brown to black; in young trees, moderately smooth, but in later life deeply longitudinally and horizontally fissured, and very rugged. The phellogen arises subepidermally; there is a very strong development of sclerenchyma and stone-cells in the primary cortex and secondary phloem, giving great strength and rigidity to these.

In young trees the bark is often less than ½ inch deep, but in mature trees and old individuals depths of ¾ to 1½ inches are attained.

Crown.—Usually semi-conical in young trees, but in adult stages the form taken is the " inverted-broom-shape," horizontally extended, with strong branches.

Foliage.—Leaves ovate to elliptical, 1–4 inches long by 1–3 inches wide; opposite, simple, petiolate, " evergreen " (they remain upon the branchlets as long as four years, according to the writer's observations on marked leaves—possibly longer); their margins strongly serrate, their dorsal surfaces dark green and glabrous except for the nerves, their ventral surfaces pale, dull green; all nerves densely rufescent. The principal anatomical features are as follows :—

Upper and lower *cuticles* well cutinised; the former 10–12μ deep, the latter 3·5–5μ. *Stomata* confined to the ventral surface, and most abundant at the extremities of the finer nerves; they have no subsidiary cells, and are very slightly sunken; well protected by rufescent hairs. Upper *epidermal* cells, 14–16μ wide by 20–25μ deep; lower epidermis less deep; lateral walls of the upper epidermis well lignified. No *hypoderm*. *Palisade* 2-rowed; the upper row usually 45–50μ deep, the lower, wider, but only about half this length. Large solitary crystals of *Ca. oxalate* are found in the palisade and in the spongy parenchyma. *Spongy parenchyma* 4–8 rows. No spicular cells or crystal-sand as in some other genera of the Cornaceae. Sclerenchyma is confined to a moderate development at the leaf-edges (where the epidermal cells too are strengthened and collenchyma-like) and to a zone 2–4 rows in width (30–35μ) surrounding the main vascular bundle. The *main vascular bundle* is half-moon shape, there being a much greater development of xylem than phloem; above the zone of protecting sclerenchyma is a well-developed mass of thick-walled collenchyma-like parenchyma, with numerous crystals therein; this mass affords great strength to the main bundle. *Hairs*: the main nerve and all the laterals and sublaterals are haired above and below, but much more densely below; the hairs are 10–12μ wide, thick-walled, unicellular or sparingly septate, and range from 300–600μ in length.

Roots.—The mean root-depths attained by adult individuals of the more important forest trees at the Knysna have been investigated by the writer. The *deepest-rooted* class is constituted by the species that show their chief root development at 30–42 inches: in this class is " Assegaai."

The tap-root persists for a time only, the ultimate form being a roughly heart-shaped mass, with numerous and long laterals.

General.—The stump *coppices* freely, and the roots give off *suckers*. At Knysna reproduction by means of coppice is an important factor in the biology of the species, the shoots developing at a rate considerably faster than rooted plants, and within a decade of the felling of the main bole, bear fruit in profusion. Natural *layers* are not formed, nor do artificially produced ones strike adventitious roots readily; as in *Ocotea bullata* E. Mey (" Stinkwood "), there is a strong sclerenchyma and stone-cell zone within the pericycle, rendering the formation of such roots difficult.

Community Relations.

So far as the Knysna forests are concerned, " Assegaai " usually is found in *climax* forest; occasionally it occurs in the penultimate stages of the forest sere, *e.g.* in the *Virgilia capensis* communities.

The best development takes place in the *Podocarpus Thunbergii* Hook–*Olea laurifolia–other* spp. association in *medium-moist* forest, the trees being more numerous and better grown, and the regeneration more abundant

and more vigorous than in other moisture types. In the *dry-type* forests, *e.g.* in the *Olinia-Pterocelastrus* associés, the stocking, growth, and vigour of " Assegaai " are inferior, the trees usually not attaining full heights exceeding 40–50 feet and girths above 3–3½ feet, the crowns being poorly developed and ultimately exhibiting " stagheads." In the *moist type* " Assegaai " is comparatively rare, scattered large trees may be found, but these regenerate poorly owing to the excessively humid and dark conditions on the forest floor.

It is present also in the *coastal* and *montane* forests, but does not attain the same sizes in these as in the forests of the plateaux.

In no community, in no type, is " Assegaai " found in pure communities, nor is it ever one of the more important dominants in the mixed associations so characteristic of the Knysna forests: it is, for example, rarely of the same status as *Apodytes dimidiata* and *Ocotea bullata*, which often are local or minor dominants or co-dominants within mixed high forest.

In the Eastern, Transkeian, Natal, and Transvaal forests it is less frequent than at Knysna. Swynnerton (1912, p. 76), however, describes it as *the commonest tree of the Chimanimani forest*, 7000 feet, Gazaland.

Habitat Relations.

The following is a brief summary of preliminary information concerning the influences of the more important habitat factors upon the species.

Light.—" Assegaai " is capable of experiencing the dense shade of the natural forests without succumbing, but develops infinitely more vigorously under higher light-intensities. As the first-stage seedlings are markedly sensitive to insolation, intensities above 0·3 to 0·2 of full sunlight do not produce good growth. Poles and large, immature trees grow faster when the naturally dense canopy of primeval forest is opened up by fellings of suitable strength; indeed, even on heavily exploited sites receiving strong insolation such stages put on appreciable girth-increment.

So far as young seedlings are concerned, the light conditions in the dense forests are definitely unsuitable. Values as low as 0·0025 to 0·0001 of full sunlight are of widespread occurrence: such cannot produce the best results in young plants. In this connection the following experiment is instructive:—

In 1924 cultures of equal-sized, almost equal-weight, first-stage seedlings of *Curtisia* were placed in containers holding soil of identical history and physical-chemical make-up. After establishment, the cultures were placed in three screens of different light-intensity, the mean moisture-content of the soil being kept at practically the same value in each culture, during the course of the experiment. As the temperature and humidity values

were more or less identical within the screens, the sole *effective* factor differing was that of light-intensity. In 1926, almost three years after, the cultures returned the following information :—

Intensity.	Mean stem length.	Fresh-weight.	Dry-weight.	Ash-weight.	General Nature.
	Per cent.	Per cent.	Per cent.	Per cent.	
0·025	285	809	920	631	Excellent.
0·005	256	666	651	490	Good, but not as fine as above.
0·002	100	100	100	100	Non-vigorous, but quite healthy.

Microscopic examination of representative leaves produced by the seedlings within the three screens showed that the mean total depths were 128μ, 112μ, and 96μ respectively, that the palisade was 2-rowed under intensity 0·005, and single-rowed in the other screens, the total depths of this tissue being about 48μ, 32μ, and 25μ respectively.

It is plain that the higher intensities produced the better plants, but it is also interesting to note that the seedlings under the low intensity of 0·002 were quite healthy despite their growing but very slowly.

The writer considers "Assegaai" to be a *semi-light-demanding* species *after* it has attained pole-size.

Temperature.—Within the Knysna area "Assegaai" is found to 3500 or 4000 feet, but favours the elevations below 2500, and from the altitudes given under "Distribution" it is evident that the species in other portions of the country is found at relatively high levels. Although it is able to put up with fairly low temperatures, "Assegaai" is extremely sensitive to *frost*, young plants being killed and older plants temporarily defoliated.

The first-stage seedlings are particularly sensitive to high temperatures of the surface-soil: *insolation-lesions*, or constrictions at the collar produced through desiccation of the cortex, being formed if the surface temperature of an exposed soil reach 150° F. and remains at or near this point for more than about half an hour. Lesioned plants die the same day or may continue to live until a second severe temperature is experienced. Older seedlings, when exposed to intense insolation, frequently suffer from *sun-scorch* of the foliage and leading shoot, the injured leaves assuming a bright red and ultimately falling. Poles and adults, even when exposed, rarely suffer from sun-scorch.

Soil-moisture.—As has been stated under "Community Relations,"

the best "Assegaai" develops in the *medium-moist-type* forest, where the mean holard at 12–18 inches depth is 45–60 per cent. (on dry-weight). On the whole, however, the species is able to withstand a fair degree of drought, provided the temperature conditions are not severe; if these be severe, wilting and death readily ensue.

Experimental regulation for fourteen months of the moisture-content of the soils of containers, in which plants of *Curtisia* were grown (20 per container), the temperature and humidity as well as the light conditions being congenial, showed the following results :—

Approximate mean holard.	Fresh-weight.	Dry-weight.	Ash-weight.	General nature.
	Per cent.	Per cent.	Per cent.	
20 per cent.	100	100	100	Non-vigorous.
40 ,,	430	297	343	Vigorous.
60 ,,	133	139	200	Non-vigorous.

The finest plants were produced in the containers of holard approximately 40 per cent., the vigour falling off considerably in those of 60 per cent.; the smallest and poorest plants were those in the 20 per cent. containers.

Organic Matter.—The leaves normally remain 2–4 or more years upon the branches; under large trees the leaves of "Assegaai" cast in the course of twelve months upon 1 square metre of the *crown-influence-zone* may be 3–5 ounces (dry-weight)—considerably less than in the instances of *Olea laurifolia* (5–10 ounces) and *Platylophus* (15–25 ounces). "Assegaai" rarely casts sufficient foliage to form a dense litter and raw-humus mat detrimental to its own aggregated regeneration, but the foliage of other species adjacent, when added to the foliage of "Assegaai," frequently brings about the formation of fairly deep beds of litter and humus. In such, germinating "Assegaai" does not thrive: apart from the existence of parasitic fungi, the beds are detrimental in that the accumulated litter inhibits the delicate radicles of the seedlings from reaching the soil proper; during dry weather the radicles are readily desiccated.

Hydrogen-ion-concentration.—While the older stages experience a wide range of *pH* values, it is distinctly noticeable that regeneration is sparse and poorly grown on sites where the *pH* values at 1–2 inches depth are lower than *pH* 4·8.

Wind.—As the species is deep-rooted and does not form a heavy crown even in its largest individuals, it is storm-firm. The branches are remarkably tough and thus rarely suffer breakage from severe winds; the foliage

normally is strongly persistent, and the flowers are moderately so. The drupes, however, are liable to be cast in large proportion during winds above 5 on the Beaufort scale.

Symbiotic Factors.—No mycorrhiza occur in the roots, and no other form of symbiosis has been detected despite special investigation. The reason for pointing out this negative condition has been explained by the writer (in a previous paper, 1928).

The Biology of the Flowers, Fruits, and Young Regeneration.

Pollination.

The inconspicuous, minute, densely *fawn-pubescent* flowers (not *red* as described by Pappe (1862, p. 19)) are crowded upon terminal, trichotomous, much-branched panicles, the axes of which are clad in dense rufescence.

The four stamens bearing versatile anthers are inserted around the margin of a fleshy disc ; the ovary is 4-celled (rarely 5), with a single pendulous ovule in each cell. The flowers are entirely odourless and there is no secretion of nectar. Pollination experiments and observations at Deepwalls over several seasons have shown that the species is almost entirely self-pollinated. The honey-bee does not visit the flowers for pollen, nor do other insects pay any serious attention to them.

Cross-pollination by agency of wind may take place.

Season and Life-history of Flower and Fruit Production.

Unlike a number of the other forest trees of the Knysna region (*vide* Phillips, 1926) " Assegaai " flowers and fruits fairly regularly.

Flowers are produced during the months October-March of *each* year by many trees, and during these months, in *alternate* years, by others. Flower crops usually produce fruit crops—a feature in which the species differs from other Knysna trees, *e.g. Olinia cymosa, Ocotea bullata, Gonioma Kamassi, Faurea M'Naughtonii,* some *Ekebergia capensis,* and some *Olea laurifolia.* Occasionally, flower crops are diseased by a gall-forming organism, and produce few or no fruits.

The following *behaviour table* (p. 36) is typical of the species at Deepwalls during normal years.

In general, mature pseudo-drupes appear six to ten months after the fertilisation of the flowers—the exact period separating fertilisation and fruit-maturity depending upon the nature of the individual tree and its general environment.

Period.	Behaviour.
(1) Early Dec. . .	Flower buds appear.
(2) Mid-Dec.–late Dec.	First flowers open.
(3) Late Dec.–early Jan.	Flowers of (2) fertilised ; earlier portion of flower-crop opening.
(4) Mid-Jan.–late Feb.	Main flower-crop opening. Flowers of (2) developing to minute, green pseudo-drupes, corollas fallen.
(5) Aug.–Nov. . .	Pseudo-drupes produced by flowers of (2) and the main crop of (4) assume cream colour, attracting birds.
(6) Dec.–Feb. . .	Ripe pseudo-drupes gradually fall or are removed by birds and bats ; late fruits gradually ripen. Flowers of the next season in position.

The Fruits and Seeds : Their Nature and Dispersal.

Nature.—The fruit is a shortly stalked globular pseudo-drupe, crowned with the minute calyx lobes ; diameter $\frac{1}{4}$–$\frac{3}{8}$ inch as a rule, exceptionally $\frac{1}{2}$ inch when fresh. The cream to yellow pericarp is succulent when fresh, corky when dry, and is bitter to the taste. Within is a hard chitinous nut, 4-celled (at times, 2-, 3-, or 5-celled), each cell containing one pendulous albuminous seed. The weight of the pseudo-drupe is most variable : for example, exceptionally large, fresh fruits from a vigorous young tree may go 30–35 to 1 ounce, whereas small, fresh fruits from an old tree may go 80–100 to an ounce.

Each panicle of a full-fruiting tree may bear up to 48 mature fruits, provided there has been no loss from disturbances by wind, birds, or bats. A large tree may bear from 2000 to 10,000 mature fruits.

Fruits are usually fairly abundant on account of the regularity of the flowering and fruiting seasons.

Fertility.—The *germinative capacity*, or proportion of viable seed per 100, ranges from 40–50 per cent., the non-viable individuals being either aborted or subnormally developed. Sowings show that in Nature about 50 per cent. of the *viable* seeds actually produce seedlings, the remainder succumbing to the rigours of the physical environment and to the ravages of biotic enemies, or being unable to endure the prolonged period of dormancy within the thick walls of the chitinous cover.

A nut may contain 0, 1, 2, 3 viable seeds, rarely 4, and very rarely 5.

Germination.—Germination is hypogeal, and normally does not take place until six to twelve months after the fall of the pseudo-drupe. In addition to the chitinous nature of the nut, the presence of the at first

succulent, ultimately corky, pericarp, appreciably delays germination; removal of this cover by artificial means slightly accelerates the rate of germination. As in the instance of *Olea laurifolia*, *Curtisia* nuts are hastened in germination on being passed through the systems of "Wild Pig" (*Potamochoerus*) and "Bush Dove" (*Columba arquatrix*).

Despite the possession of the corky covering and the chitinous walls of the nut, the seeds do not lie dormant for more than fifteen to eighteen months; in very many instances they are decayed before they have lain nine months upon the forest floor. A factor retarding germination and therefore conducive to dormancy is the dense layer of leaf-litter upon the forest floor, unless this litter be wet.

Dispersal.—The majority of the pseudo-drupes aggregate under the parent: as many as 100–300 may be found per square metre of the *crown-influence-zone* of heavily fruiting individuals. Such aggregations result in the appearance of exceedingly dense seedling communities.

The agents of dispersal of importance are *Turacus corythaix* ("Loerie") and *Columba arquatrix* ("Bush Dove"), which take ripe fruits from the panicles, swallow the nutlets, and void these mostly unimpaired, at distances up to several miles from the point of feeding. Fallen fruits are removed in large numbers by "Wild Pig" and to a slight extent by Monkey and Baboon.

Regeneration.—The seedlings appear with delicate, entire cotyledons, which remain in position for many weeks or months according to the rate of growth of the seedling and the conditions of the habitat: the faster the growth the sooner they are shed. The primary leaves develop within several weeks of appearance of the radicle; these are always serrate and haired.

The seedling is vigorous from the commencement, but at the same time is highly susceptible to injury from drought, high surface soil temperatures, and "damping-off" fungi. For the first few days it closely simulates the seedling of *Cluytia pulchella*.

Cotyledon-stage plants at certain spots are as abundant as 100–200 per square metre of the *crown-influence-zone*, and, in general, are well distributed throughout the *dry* and *medium-moist* forest types.

Owing to the severity of the mortality factor, the overwhelming majority of the cotyledon-stage plants succumb ere they attain the primary-leaf-stage. Owing to the large fruit output, however, there are usually large numbers of seedlings of this latter stage available in the more congenial sites.

The various height and girth classes of older seedlings, saplings, and poles are well represented wherever the environmental and community conditions are suitable.

So far as adequate regeneration from seed is concerned, there is no reason why the stocking of this valuable timber species should not be increased to a considerable extent. This increase will be possible through the media of provision of better *germination*, *establishment*, and *growth* conditions in the *dry* and *medium-moist* types—such improvement of conditions being possible through removal of the dense light-reducing moisture-voracious layers of large woody shrubs such as *Trichocladus crinitus* and *Burchellia capensis*, and non-economic spp. of trees, such as *Olea capensis, Plectronia obovata, Royena lucida.*

Regeneration by means of coppice is excellent.

Rate of Growth.

In untended high forest in which practically no felling has been carried out, the mean girth increment of poles, small trees, and large but still immature trees is not great: the following mean data obtained from a fairly large number of trees gives some impression of the conditions obtaining :—

Girth-class (inches).	Mean annual girth-increment (inches).
3–6	0·07
7–12	0·13
13–18	0·19
19–24	0·21
25–30	0·22
31–36	0·18
37–42	0·15

In suitably tended forest the increments are higher, for example :—

Girth-class (inches).	Mean annual girth-increment (inches).
25–30	0·52
31–36	0·45
37–42	0·52

Seedlings in dense forest grow in height at the rate of less than 1 inch to 6 inches per annum, but in exploited and tended forest, where the light conditions are better and the degree of competition for moisture less

severe, the rate increases to 9 to 12 inches, exceptionally to 18 inches, per annum.

Coppice shoots develop at the rate of 1 foot to 4 feet per annum for the first few years, and thereafter at about 6 to 12 inches per annum; their girth-increment ranges from 0·5 to 1·5 inches per annum.

Mortality Factors.

The species suffers from the following pests and diseases :—

The Flowers.—Inflorescences frequently are very severely galled—the galls being from $\frac{1}{2}$ to $\frac{3}{4}$ inch in length by about $\frac{1}{4}$ to $\frac{1}{2}$ inch wide and deep, irregularly shaped, and very densely rufescent. Sim (1907, p. 231) states that a fungus is the causal organism; Marloth (1925, p. 236) corroborates this statement; Phillips (1926, p. 380) formerly considered that the damage done was the work of a sterile fungus that not infrequently is found within the hypertrophied tissues. More recently, however, he has had reason to believe that the agent responsible is a minute Eriophyid.

At times small Lepidopterous larvae may be found within the galls, but the writer is of opinion that these, while being responsible for a certain additional amount of stimulation of the tissues, are in reality secondary.

The damage produced in some inflorescences is really considerable, not a single flower being able to produce fruit. Some inflorescences show definite galled branchlets only, others show almost every inflorescence galled, others a few only. It is noteworthy that trees bearing galled inflorescences one season almost invariably bear galled ones in following years.

The Fruits and Seeds.—On the trees the fruits and seeds are not attacked by either fungi or insects. On the ground, while awaiting decomposition of the pericarp and of the chitinous walls of the nut, the seeds are liable to the ravages of several dipterous larvae and mould-fungi. Almost 50 per cent. of the viable seeds succumb, and a fair proportion of the deaths is due to these biotic agents.

The Seedlings.—*Fusarium* spp. annihilate large communities of cotyledon-stage seedlings—the infection spreading exceedingly rapidly. Plants in moist, poorly illuminated sites, and in soil of low *pH* value, are the most susceptible.

Pestalozzia sp. nov. also does much damage in plants of this stage, constricting them at or near the collars.

Older plants sometimes are much impaired by the attacks of *Meliola ganglifera*, which forms dense colonies upon the foliage and shoots; seedlings attacked severely succumb.

The Older Stages.—Boles of older trees are attacked by the facultative parasite *Fomes applanatus* (Pers.) Gill., which sets up decay, and is responsible for decreased vigour, and sometimes death, of numerous mature and over-mature trees.

Fomes oroflavus and *F. Yucatensis* are responsible for a certain amount of damage, producing decay in the boles of older trees. Another destructive fungus, often found together with *F. applanatus*, is *Trametes glabrescens.*

Summary.

1. *Curtisia faginea* Ait., "Assegaai," an important tree sylviculturally and economically, is generally described as to distribution, habit, community, and habitat relations; the principal features in the biology of the flowers, fruits, and young regeneration are outlined; some data *re* growth are given, together with an account of the principal factors of mortality.

2. *Curtisia* is best developed in the Knysna forests, although it ranges from the Cape Peninsula to the forests of Gazaland. It is very rarely a dominant, and still more rarely occurs in pure communities.

3. It is most at home in the *medium-moist* type forest at Knysna; while its regeneration stages can experience deep shade without dying, these develop infinitely better when provided with fairly strong light; in pole and later stages the species is definitely *semi-light-demanding.*

4. The plant flowers regularly, fruits fairly regularly and heavily; the fruits are of moderate fertility; they are dispersed principally by the "Loerie" and the "Bush Dove," but the greater number aggregate at the base of the parent.

5. The rate of growth in girth is slow, but compares favourably with that shown by other spp. of the Knysna forests, *e.g. Olea laurifolia, Gonioma Kamassi.*

6. An Eriophyid forms galls upon the inflorescences, these galls often resulting in the loss of a large portion of the fruit-crop.

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ON SOME NEW SPECIES OF BACTERIA ISOLATED FROM *XENOPUS LAEVIS*.

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In the course of investigations into the reflex times of spinalised and decapitated frogs, it has often been noticed that quite a number of frogs which had survived the shock of the initial operation developed later on, at the site of the wound and around the stitches, a peculiar mould-like mass. These infected frogs (*Xenopus Laevis*) died earlier than non-infected ones, in a marasmic condition. In some cases the mould-like mass developed in spite of the previous application of "Bipp."

A large specimen of *Xenopus Laevis* was anaesthetised by immersion in 1 per cent. ether water. When completely under this anaesthetic its skin was cut over the dorsum of its head, the superior aspect of its skull was scraped, and a part was sawn out with a dentist's burr. The cerebral hemispheres were removed, the wound rubbed with "Bipp," and the skin-flaps approximated and stitched with three cat-gut stitches. The whole operation was performed under the strictest aseptic precautions, and the frog was then replaced in its tank.

Ten days later a mould-like mass appeared which grew larger, till finally it covered both the wound and the ligatures. On lifting the mass up, it was found to be organised to the underlying tissues. The frog was washed in sterile water; with a sterile needle some of this hard mass was removed and smeared on to plates of agar-agar, blood-agar, and serum-agar respectively. The plates were incubated at room temperature for twenty-four hours, and the best growth was observed on the serum-agar.

On this plate of serum-agar three distinct types of colonies, and three only, could be seen. Typical colonies of each type were picked off, emulsified in sterile water, and smeared on to agar plates. These proved to be colonies of three different organisms which are here referred to as "A," "B," and "C." The agar-agar and the blood-agar plates likewise showed colonies of these three distinct organisms.

Cultural Characters.

Organism "A."

The organism is a small, rod-shaped bacillus about 0·5 by 1·5 microns; it occurs singly. It possesses rounded ends, and is motile by means of peritrichous flagella. It is Gram Negative.

Agar colonies of twenty-four hours' growth at 20° C. are white and about 2 mm. in diameter. They possess entire edges. Similar colonies were observed on serum-agar, blood-agar, and blood-serum. All these cultures possess an odour of decomposing shellfish.

Gelatin stabs are rapidly liquefied with a crateriform formation. Growth was observed only on the surface of the gelatin. After several weeks the gelatin is entirely liquefied, and a greenish colour is imparted to the fluid.

Broth shows a uniform turbidity with no pellicle. A moist shining growth was seen both on potato and on alkaline potato.

Litmus-milk is acidified, but is not coagulated. Indol is formed from peptone water, nitrates are not reduced to nitrites, and acetyl-methyl-carbinol is not formed from glucose.

Acid and gas are formed from glucose, lactose, maltose, mannite, galactose, laevulose, rhamnose, xylose, and arabinose.

The organism is aerobic, and its optimum temperature is 20° C.

Organism "B."

This organism is also a small, rod-shaped bacillus. It is motile, occurs singly, and is Gram Negative.

Agar colonies of twenty-four hours' growth at 20° C. are smaller than "A's," being then about 1·0 mm. in diameter. They are white with entire edges, and have more shelving margins than "A's." They are softer to the needle and do not break up on touching. The colonies tend to be confluent. Similar colonies are seen on serum-agar, blood-agar, and blood-serum. The colonies possess a fishy odour.

Gelatin stabs are liquefied with crateriform formation. This occurs less rapidly than with organism "A," and is also ultimately complete. Growth is observed only on the surface of the gelatin.

Broth shows a uniform turbidity with no pellicle. A white, moist, shiny growth is observed both on potato and on alkaline potato.

Litmus-milk is unchanged, indol is not formed, and nitrates are not reduced to nitrites. Acetyl-methyl-carbinol is not formed from glucose.

Acid is formed from glucose and xylose only.

The organism is aerobic. Its optimum temperature is 20° C.

Organism "C."

The organism is a small rod-shaped bacillus. It is non-motile, occurs singly, and is Gram Negative.

Agar colonies of twenty-four hours' growth at 20° C. are small, being about 0·5 mm. in diameter. The margins are sheer, and the edges entire. The colonies are discrete, hard to the touch of the needle, and tend to come off the medium altogether on touching. Similar colonies appear on serum-agar, blood-agar, and blood-serum. The cultures have a characteristic odour reminiscent of the seashore.

The growth of this organism on similar media is much slower than either "A" or "B." Its colonies are very easily seen on any medium owing to their yellowish opacity and sheer margins. Three days are necessary for clouding to be observed in peptone water, as compared with twenty-four hours in the cases of "A" and "B."

The agar colonies originally possessed a lemon-yellow colour, due to some pigment which tended to diffuse through the medium. This chromogenic property was lost after the first few transplantations.

Gelatin stabs are liquefied very slowly also with crateriform formation. Ultimately liquefaction is complete.

Broth cultures show turbidity with no pellicle. A discrete growth is observed on potato and a moist confluent growth on alkaline potato.

Litmus-milk is unchanged in reaction, indol is not formed, and nitrates are not reduced. Acetyl-methyl-carbinol is not formed from glucose.

Acid is formed from glucose, galactose, and xylose.

The organism is aerobic ; its optimum temperature is 20° C.

Experimental.

Neither intraperitoneal nor subcutaneous injections into normal frogs of organisms "A," "B," or "C" respectively produced any symptoms of disease ; "B's" injection, however, produced a slight transient illness. Scarifying the skin and rubbing in the organisms separately into three different frogs likewise gave no results. When a mixture of "A," "B," and "C" was injected intraperitoneally or subcutaneously into frogs, the animals died in a comatose condition within forty-eight hours. On scarifying the skin and rubbing the mixture of the three organisms on to the scarified area, the frog died in three days.

Intraperitoneal injection of one agar slope (twenty-four hours' growth) of organism "A" emulsified in 0·5 c.c. saline into a guinea-pig, killed the animal in eighteen hours. On post-mortem it was found that the heart was enlarged, the lungs haemorrhagic, and the suprarenals congested with haemorrhages into their substance. A copious serous exudate swarming

with bacilli was found in the peritoneal cavity. The organism was isolated in pure culture from the heart, peritoneal fluid, and spleen. A septicaemia is therefore produced.

A white mouse inoculated in a similar way with an identical dose died within twelve hours. Its spleen was greatly enlarged, its lungs were congested, and its peritoneal contents were oedematous. The organism was isolated in pure culture from the heart and spleen. These findings are likewise typical of a septicaemia.

On injection of a whole agar slope (twenty-four hours) of organism "B" emulsified in 0·5 c.c. saline into a guinea-pig intraperitoneally, no effect was produced. A similar injection into a white mouse caused death within twenty-four hours. The organism was recovered in pure culture from the spleen, peritoneal cavity, and heart's blood. A septicaemia is thus produced. Mice injected with half-slopes of the growth on agar (twenty-four hours) became very ill for two days, but recovered later.

Identical injections of organism "C" into a guinea-pig killed the animal in thirty-six hours. There was incontinence before death. A fibrinous peritonitis was found post-mortem, the heart and lungs were engorged, but there was no excessive splenic enlargement. The organism was isolated in pure culture from the heart's blood.

A white mouse injected with a similar dose died in eighteen hours. On autopsy the liver, spleen, and lungs were found to be engorged, the spleen being in addition slightly enlarged. On plating out smears from the heart and spleen, a very mixed growth occurred.

Classification.

The three organisms here described belong, judging by their cultural characters, to three different genera.

Organism "A" has cultural characters which give it a marked resemblance to the *Escherichia*; however, it liquefies gelatin. Wolffin (1) describes an *Aerobacter Levans* isolated from fermenting dough; this, however, forms acetyl-methyl-carbinol from glucose: Hollinger (2) describes a similar organism to Wolffin's. Hammer (3) describes an *Escherichia Icthyosmia* isolated from evaporated milk, and this liquefied gelatin. This, however, forms acid and gas from saccharose, and indol from peptone water. Its colonies have a fishy odour. Ford (4) describes an *Escherichia Plebeia* isolated from the intestinal canal, which also liquefies gelatin. Its agar colonies are opaque in the centre, and the margins have radiating strands and are translucent. Milk is acidified and later alkalised, and growth on potato is first yellowish-white, then brown, and finally red.

Organism "B" belongs to the genus *Eberthella*. Ford (*loc. cit.*) describes

an *Eberthella Oxyphila* isolated from the intestinal canal. This reduces nitrates and acidifies milk. The same author describes an *Eberthella Chylogena*, which also acidifies milk, and whose colonies on agar are pale brown with no characteristic odour. Bleisch (5) and Flügge (6) describe an *Eberthella Dubia*. This acidifies and clots milk, reduces nitrates and gives a yellowish-brown growth on potato. It also forms indol and was isolated from the intestinal canal. Its optimum temperature is 37° C.

Organism "C" belongs to the genus *Flavobacterium*. Copeland (7) describes a *Flavobacterium Brunneum*. This gives a clear growth in broth, a reddish-brown growth on potato, and has an optimum temperature of 30° to 35° C. Vignal (8) describes a *Flavobacterium Buccalis*. This gives a smooth, yellow, filiform growth on agar, forms an iridescent pellicle on broth, and gives a yellowish-white, beaded growth along the gelatin stab. Its optimum temperature is 30° C.

	Organism "A."	Organism "B."	Organism "C."
Gram	—	—	—
Motility	+++	+	—
Glucose	AG	A	A
Lactose	AG	—	—
Maltose	AG	—	—
Mannite	AG	—	—
Dulcite	—	—	—
Saccharose	—	—	—
Galactose	AG	—	A
Laevulose	AG	—	—
Rhamnose	AG	—	—
Adonite	—	—	—
Inulin	—	—	—
Sorbite	—	—	—
Dextrin	—	—	—
Salicin	—	—	—
Raffinose	—	—	—
Inosite	—	—	—
Xylose	AG	A	A
Arabinose	AG	—	—
Haemolysis	—	—	—
Acetyl-methyl-carbinol	—	—	—
Indol formation	+	—	—
Nitrates	Not reduced.	Not reduced.	Not reduced.
Milk	A	—	—
Broth	Turbid.	Turbid.	Turbid.
Gelatin liquefaction	+++	++	+
Optimum temperature	20° C. Aerobic.	20° C. Aerobic.	20° C. Aerobic.

(A=acid formed. G=gas formed.)

Discussion.

While the mould-like disease itself could not be reproduced in frogs by injection of the organisms separately or together, a mixed infection with all three appears to be very virulent for these animals. Mere rubbing on to a scarified area of skin of a single loopful of each organism is sufficient to cause a fatal infection.

It is highly probable that the normal habitat of the organisms is tap water. The only contamination of the wound occurs when the frog is replaced in its tank, and there tap water drips on it all day long. The best method of treatment is to remove the growth and to keep the raw surface exposed well covered with "Bipp." The condition usually clears up within a week.

Bacterial parasites capable of infecting frogs are comparatively rare. Sanarelli (9) and Emerson and Norris (10) describe a *B. Hydrophilum-fuscus* which causes "red-leg," a septicaemic disease in amphibians. Dubarre and Terre (11) describe an acid-fast bacillus causing a granulomatous lesion in frogs; they call it *B. Tuberculosis Ranae.* Bergey (12) quotes Küster (13) as describing this organism fully under the name of *Mycobacterium Ranae.* Scott (14) describes a mycotic disease in frogs, the casual organism of which is a mould, *Monilia Batrachea.*

I would like to suggest that organism "A" be classified as *Escherichia Alba*, organism "B" as *Eberthella Xenopa*, and organism "C" as *Flavobacterium Flavotenue.*

Summary.

1. Three new organisms have been described and named.
2. These have been isolated from a mould-like growth on a frog (*Xenopus Laevis*).
3. The disease could not be reproduced by inoculation with various methods.
4. A mixed infection with all three organisms is highly pathogenic to frogs.

The author wishes to express his thanks to Professor W. Campbell for his helpful advice and for the facilities provided in his laboratories, and to Professor W. A. Jolly for his kind interest in this work.

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COLOUR AND CHEMICAL CONSTITUTION.

Part XXIV.—A Complete Investigation of the Triphenylcarbinol or "Aniline" Dyes.

By James Moir.

Some apology might seem needful for reopening this nearly fifty-year-old subject. The author has already added new data in Part X (1920) and Part XVI (1923) and laid the foundation of a quantitative explanation of the absorption-bands of these interesting and remarkably simple coloured compounds, and in Part XIII (1922) connected them up (in their acid condition) with fuchsone and other still simpler absorbing compounds. These investigations, however, only dealt with about 70 per cent. of the possible substances.

The coming on the market of such very useful substances as acetaminobenzaldehyde and dimethylaminobenzaldehyde has enabled the author to synthesise and examine the *complete* series of possible diphenylcarbinol and triphenylcarbinol dyes—twenty-three in all.

These twenty-three were found to possess no less than seventy-five absorption-bands amongst them; and the author has tackled the apparently formidable problem of explaining them all in terms of chemical constitution as modified by varying hydrion-concentration, with quite a fair degree of success.

As was found necessary in Part X of this series (These *Trans.*, VIII, 1920, p. 303) it is necessary to assume that all are constitutionally related to a fundamental substance of known absorption. This substance is *bis-p*-hydroxyphenyl-carbinol (*p-p*-dihydroxybenzhydrol). An attempt to explain the fundamental absorption of this substance itself from first principles of molecular geometry was made some time ago by the author (J. Chem. Soc. London, 1922, p. 1811).

Taking HO$\langle\quad\rangle$CHOH—$\langle\quad\rangle$OH (or HO$\langle\quad\rangle$—CH : $\langle\quad\rangle$: O) as the fundamental substance, with absorption at λ 539, and assuming the factor for replacement of —OH by NH_2 to be 1·008 and the one for replacement of —OH by NMe_2 to be 1·058, we get the following striking results :—

1. Calculated λ of aminohydroxybenzhydrol (alkaline),
   NH_2⬡CHOH—⬡ONa=543 (observed value=541).
2. Calculated for diaminobenzhydrol (acidic),
   NH_2⬡—CHOH—⬡$NH_3\bar{A}$=548 (observed value=548).
3. Calculated for dimethylaminohydroxybenzhydrol (neutral or alkaline),
   HO⬡—CHOH—⬡—NMe_2=570 (observed value=571).
4. Calculated for aminodimethylaminobenzhydrol (acidic),
   Me_2N⬡—CHOH—⬡$NH_3\bar{A}$=574½ (observed value=574).
5. Calculated for tetramethyldiaminobenzhydrol (acidic),
   Me_2N⬡CHOH—⬡$NHMe_2\bar{A}$=603 (observed value=603).

These are all the possible cases. From these we can pass to the malachite-green type of triphenylcarbinol dyes. The factor for replacing H in the centre by C_6H_5 (or Ph) is found to be 1·025, and the following equally striking agreements are found :—

A. Calculated λ of benzaurine, HO—⬡—CPhOH—⬡OH =1·025 × λ of fundamental substance=552½ (observed value=553).

B. Calculated λ of aminofuchsone,* HO—⬡—CPh : ⬡ : NH or NH_2⬡—CPh : ⬡ : O,=1·025×No. 1 above=556½ (observed value=558).

C. Calculated for Doebner's-violet, NH_2—⬡—CPh : ⬡ : $NH_2\bar{A}$, 1·025×No. 2 above=561½ (observed value=562).

D. Calculated for dimethylaminofuchsone, HO⬡—CPhOH—⬡NMe_2, 1·025×No. 3 above=584½ (observed value=585, in neutral solution).

E. Calculated for dimethylaminofuchsonimonium chloride, NH_2⬡—CPh : ⬡ : NMe_2Cl, 1·025×No. 4 above=589 (observed value=590).

F. Calculated for malachite-green, Me_2N—⬡—CPh : ⬡ : NMe_2Cl, 1·025×No. 5 above=618 (observed value=618).

This table again covers all the possible cases. Substance E is malachite-green minus two methyl groups and is of a bluish-violet colour.

We have thus correctly (*i.e.* within ¼ per cent.) calculated the absorptions of these eleven substances from their chemical constitution, using only three factors, and these eleven substances are all that can exist of this class.

The explanation can be taken a little farther by comparing the tri-

* Fuchsone is $Ph_2C(OH)$—⬡OH.

auxochrome triphenylcarbinols with the substances 0 to 5 (the di-auxochrome diphenylcarbinols). There are ten of these possible, and all of them have *one* of their bands almost coincident with the band of the corresponding substance in the list 0 to 5.

α. Aurine, $C(OH)(-⬡OH)_3$ has λ 534 in alkali (*cf.* $CHOH(-⬡OH)_2$ λ 539 in alkali). In acid they have λλ 485 and 487 respectively.

β. Parafuchsine, $C(OH)(-⬡NH_2)_3$ has λ 543 neutral and λ 572 acidic (*cf.* $CHOH(-⬡NH_2)_2$, No. 2 above, λ 548 acidic and λ 580 more acid).

γ. Crystal-violet, $C(OH)(-⬡NMe_2)_3$ has λ 596 when neutral (*cf.* $CHOH(-⬡-NMe_2)_2$, No. 5 above λ 603).

The multiplying factor for calculating the λ of the 3-ring compound from the λ of the corresponding 2-ring compound is 0·99.

∂. Aminobenzaurine, $C(OH)(-⬡OH)_2(-⬡NH_2)$ has λ 555 in alkali and λ 495 in acid (*cf.* $CHOH(-⬡OH)(-⬡NH_2)$, No. 1 above, λλ 552 and 492 *in acid*) (541 in alkali). Note that although the bands correspond as before, one is in alkali and the other in acid: the *p*H is not the fundamental condition, but suitable ionisation whether acid or alkaline.

ε. Diaminofuchsone, $C(OH)(-⬡OH)(-⬡NH_2)_2$ has a band in the same place as aminobenzaurine (obs. λ 556) but this time it is exhibited in *acid* solution. The comparison substance is the same as for ∂ and has λ 552.

ζ. Dimethylaminobenzaurine, $C(OH)(-⬡OH)_2(-⬡NMe_2)$ has λ 575 neutral (*cf.* $CHOH(-⬡OH)(-⬡NMe_2)$, No. 3 above, λ 571 neutral.

η. Tetramethyldiaminofuchsone, $C(OH)(-⬡OH)(-⬡NMe_2)_2$ has a band almost in the same place as the foregoing, but it requires *alkaline* solution (λ 573). The comparison substance is the same as for ζ (No. 3 above) and has λ 571.

θ. Dimethylparafuchsine, $C(OH)(-⬡NH_2)_2(-⬡NMe_2)$ has a band at λ 587, neutral (*cf.* $CHOH(-⬡NH_2)(-⬡NMe_2)$, No. 4 above, which exhibits the corresponding band, λ 590, not when neutral but when acid. [It has λ 574 when neutral.]

ι. Tetramethylparafuchsine, $C(OH)(-⬡NH_2)(-⬡NMe_2)_2$, also known as "aminomalachitegreen," has a band in the same place

as the foregoing when neutral (obs. λ 586). No. 4 is again the comparison-substance, λ 590 acid.

κ. Dimethyldiaminofuchsone or hydroxyaminodimethylaminotriphenylcarbinol, $C(OH)(-\langle\;\rangle OH)(-\langle\;\rangle NH_2)(-\langle\;\rangle NMe_2)$ has a band at λ 590 when neutral and may be compared with θ and ι above.

Thus all of these ten have *one* explicable band, but of course a substance like the last one (κ), with three different auxochromes and eight or nine different ways of arranging the quinonoid linkage, has many other bands, which are much more difficult to explain.

Fourthly, the di-auxochrome triphenylcarbinols can be correlated with the tri-auxochrome triphenylcarbinols by cross-correlation between substances A to F and substances α to κ. For A, C, and F (the symmetrical substances) compared with α, β, and γ (also symmetrical) the multiplying factor is 1·033. For A, B, D, etc., in the *acid* state compared with α, ∂ (or ϵ), ζ (or η), the deviation from unity is about half of this (factor 1·016), whilst for the remaining substance E (*cf.* θ, ι, and κ) it is still less, viz. 1·007.

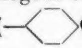
The explanation of the whole of this is that the electron-movement causing the colour is (1) the same for 3-ringed symmetrical substances as for 2-ringed substances containing the same auxochromes ; (2) nearly the same, *i.e.* the same but slightly perturbed in 3-ringed substances with only two symmetrical auxochromes ; (3) similar but markedly perturbed when the *inactive* auxochromes have markedly different effects from one another (NMe_2 as compared with the other two) ; and (4) still more dissimilar when the active auxochromes are different (unsymmetrical).

The facts that (1) substances 0 and α (about 537),
(2) ,, 2 and β (about 546),
(3) ,, 5 and γ (about 600),
(4) ,, 1, ∂ and ϵ (about 554),
(5) ,, 3, ζ and η (about 573),
(6) ,, 4, θ, ι, and κ (about 590)

have each got a band in common is of fundamental theoretical importance. The first three pairs lead to the conclusion that when three rings containing the same auxochrome are present, the effect is due to only two of them, the other remaining almost inactive. The theory of trefoil instead of elliptical orbits proposed by the author in 1921 (J. Chem. Soc. London, 119, p. 1664) would meet the case if modified to suit modern notions of atomic orbits by transferring the motion to the electrons of the central carbon atom moving under the influence of either two or three outside positive forces placed nearly symmetrically round it.

The motion may possibly be merely an in-and-out "jump" of

the usual emission-absorption type occurring simultaneously in either three (trefoil case) or two (ellipse case) of the electrons of the central carbon.

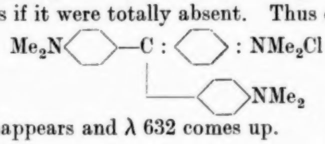
Now we should expect, if this is the correct theory, that since substance ∂ when examined in alkali has the $C_6H_4NH_2$ group rendered inactive and substance ζ similarly has the $C_6H_4NMe_2$ inactive, the bands so exhibited should be analogous to those of the other substances containing the active combination (—OH)$_2$, viz. benzaurine (A) and aurine (a), but that there should be no correspondence in acid solution.

Now in alkali ∂ has λ 555, A has λ 553 and a has λ 534 (548 at pH8), whilst ζ has $\lambda\lambda$ 548 and 497. In acid ∂ has λ 495, A λ 493, a λ 485, but ζ has $\lambda\lambda$ 552 and 507. Thus the theory is on the whole supported although substance ζ has two extra bands which disagree.*

Again, we should expect, if the theory is correct, since substances ϵ and η when examined in acidic solution have the C_6H_4OH group inactive, that their bands should be analogous to those of the others containing the active combination (—NH$_2$)$_2$ and (—NMe$_2$)$_2$.

Accordingly we find that (in acid) substance ϵ has $\lambda\lambda$ 556 and 433, substance C has λ 562, and substance β has $\lambda\lambda$ 543 and 572. Similarly we find that substance η in acid has $\lambda\lambda$ 605 and 460,† substance F has λ 618, and substance γ has $\lambda\lambda$ 632 and 596. Thus the theory is fully supported except for the appearance of extra bands, so far unexplained.

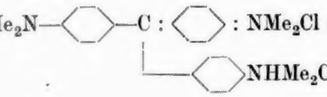
The remaining class, that including the $(NH_2)_2NMe_2$ and $(NMe_2)_2NH_2$ combinations, cannot be tested experimentally because it is not possible to render —NH_2 inactive by alkali without also rendering —NMe_2 inactive. In acid solution, however, they follow the example of diaminofuchsone just mentioned, agreeing with theory: substance κ in acid (with —OH inactive) has $\lambda\lambda$ 590 and 420; substance E has λ 410 (λ 590 neutral) and substance 4 has $\lambda\lambda$ 591 and 491, this last band being abnormal.

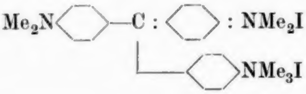
It is an important point that the electronic movement causing the high colours cannot take place unless there is a balance or competition between two (or more) positive centres for a single electron. When one of the NH_2 or NMe_2 groups is made fully ionised by means of mineral acid, it behaves almost as if it were totally absent. Thus crystal-violet of λ 596 of the constitution 

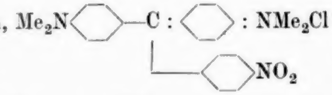
turns green when made acid: λ 596 disappears and λ 632 comes up.

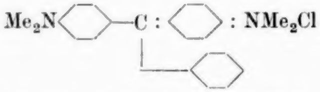
* Substance ζ has a fifth band when exactly neutral, λ 575, corresponding to substance 3 (*vide supra*) (see Table at end).

† It has λ 573 in alkali.

The constitution is now  and may be compared with

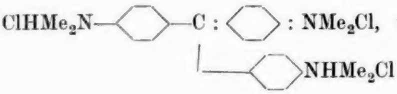
(1) Iodine-green,  of λ 634.

(2) *p*-nitro-malachite-green,  of λ 646.

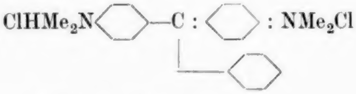
(3) Malachite-green,  of λ 618.

(4) *p*-aminomalachite-green (as (2) with NH_3Cl for NO_2) of λ 628, showing conclusively that the group  fully ionised is merely a loaded benzene ring.

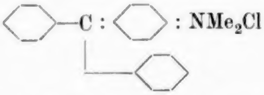
The matter can be taken a step farther. The green solution of acidic crystal-violet goes yellow with a lot of mineral acid: $\lambda\lambda$ 596 and 632 both disappear and λ 417 comes up. The product has the constitution

 which may be compared with:

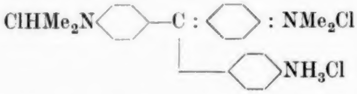
(1) Acidified malachite-green,

 of λ 440.

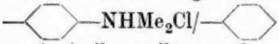
(2) Fuchsonedimethylimonium chloride,

 of λ 455.

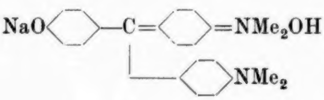
(3) Acid tetramethylfuchsine (aminomalachite-green),

 of $\lambda\lambda$ 420 and 460.

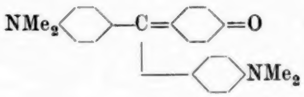
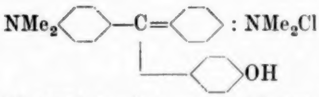
showing that a second  again behaves as a mere

loaded benzene ring. Put in the form of a colour-factor the ratio for  is 1·02.

A similar yellow analogue of fuchsonedimethylimonium chloride (with only one active auxochrome) is formed on acidifying the violet substance E (change from 590 to 410), but dimethylparafuchsine (substance θ) behaves somewhat differently, probably because (as explained already) all the groups are attacked by acid simultaneously. It has $\lambda\lambda$ 587 and 455 when neutral (the lower one agreeing with theory) and $\lambda\lambda$ 549 and 499 when acid, *i.e.* it agrees with theory but has three extra for-the-nonce unexplained bands. The band at λ 460 of substance η is of similar origin, for when both the NMe_2 groups are rendered inactive by mineral acid the substance becomes a highly loaded fuchsone. We have, in fact, for tetramethyldiaminofuchsone the series of constitutions :

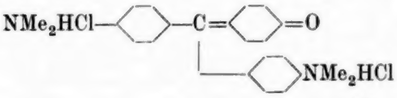
 of $\lambda\lambda$ 573 and 505 (*cf.* substance 3 of λ 571),

(alkaline)

 or 

of λ 605 (*cf.* substance 5 of λ 603),

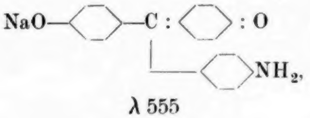
(neutral)

 of λ 460 (*cf.* fuchsone of λ 371).

(acid)

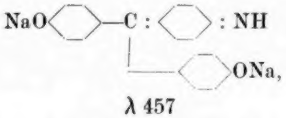
Similarly substance ϵ (the foregoing without methyl groups) has $\lambda\lambda$ 556 and 492 in acid, λ 580 neutral and λ 433 in strong acid, *i.e.* the foregoing phenomena are repeated farther down the light-scale, so that the visual change is from rose to yellow through purple instead of from violet to yellow through green.

Conversely the combination with two OH groups and one NH_2 gives :



λ 555

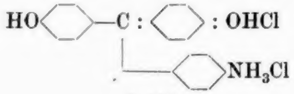
(faintly alkaline)



λ 457

(strongly alkaline)

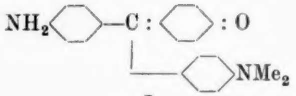
and



λ 495
(acid)

and there is no low band *because there are not two acidic groups to be destroyed by acid.* Similarly substance B (with only one NH_2 group) gives λ 558 in alkali, λ 564 neutral and λ 499 in acid, and does not follow fuchsonimonium chloride (λ 425) but follows substance 1 (λ 541 alkali, λ 552 neutral, and λ 492 acid).

All of the substances possible have now been discussed with the exception of κ, the one with three different auxochromes. As already mentioned, this single substance has a large number of theoretically possible quinonoid forms, which are tabulated below :



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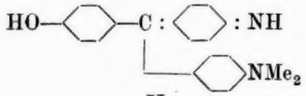

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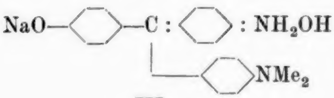

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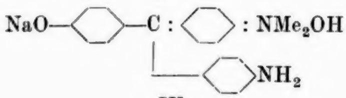

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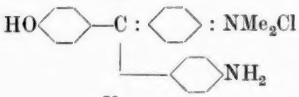

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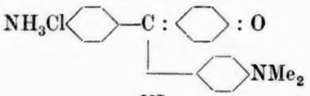

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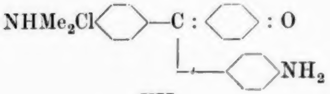

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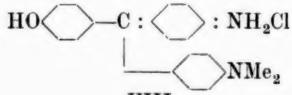

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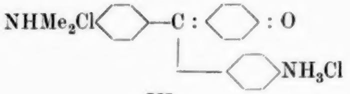
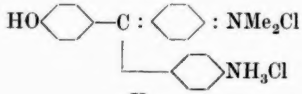
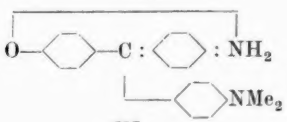


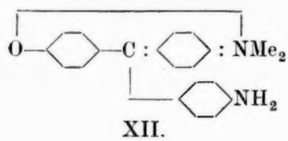
IX.



X.



XI.



XII.

Its alkaline solution can be represented by formulae III or IV; its neutral state by formulae I, II, XI, or XII; its acidic state by formulae V, VI, VII, or VIII; and its fully acid state by formulae IX or X. It appears, however, to have only six different bands, one of these, λ 590, appearing *in all solutions* except the strongly acid one.

The alkaline phase has also $\lambda\lambda$ 489 and 453; the neutral phase has also λ 545; the acidic has λ 624 (and λ 590), and the acid one λ 420. Formulae IX and X when looked on as ionised, become identical (*i.e.* tautomeric) and agree by theory with λ 420 (see p. 55 for theory). Formulae I, II, XI, and XII are also tautomeric variants of one another and agree by theory with $\lambda\lambda$ 590 and 545: formula V agrees by theory with λ 624: but the lower bands in alkali disagree with theory. Bands at about these places occur in a number of the $(OH)(NH_2)$ compounds already discussed and have there been remarked on as abnormal. I conclude that in addition to the "elliptical" and "trefoil" atomic motions there must be a third (less common) one, conditioned by the combinations $(ONa)(:NH_2OH)$ and $(ONa)(:NMe_2OH)$. Since it gives low bands it is probably a perturbed circular one such as exists in fuchsone and other *monocyclic* colours.

[Table.

In conclusion a tabular summary of the observations is given :

TABLE.

Oxygen Compounds.	λ	Nitrogen Compounds. NH$_2$ type.	λ	NMe$_2$ type.	λ
p-hydroxybenzyl alcohol	293	NH_2⬡CH_2OH	335	Me_2N⬡CH_2OH	390
p-hydroxybenzhydrol .	320	NH_2⬡$CHPhOH$	350	Me_2N⬡$CHPhOH$	400
Fuchsone . . .	371	NH_2⬡CPh_2OH	425	Me_2N⬡CPh_2OH	455

	$\lambda\lambda$
Benzaurine	553, 493, 455
Aminofuchsone	558, 564, 499
Dimethylaminofuchsone	585, 530, 500
Doebner's violet	562, 582 faint, 497, 380
Aminofuchsonedimethylimonium chloride	590, 410
Malachite-green	618, 440
Dihydroxybenzhydrol	539, 487, 450
Aminohydroxybenzhydrol	541, 552, 492
Dimethylaminohydroxybenzhydrol	571, 563
Diaminobenzhydrol	548, 580, 495
Dimethyldiaminobenzhydrol	574, 591, 491
"Michler's carbinol"	603, 565 very faint, 380
Aurine	534, 485, 548, 503
Parafuchsine (pararosaniline)	543, 572, 360
Crystal-violet	596, 632, 417
Iodine-green	634
Aminobenzaurine	555, 495, 457
Dimethylaminobenzaurine	575, 548, 552, 507, 497
Diaminofuchsone	580, 556, 433, 492
Tetramethyldiaminofuchsone	605, 573, 505, 460
Dimethylpararosaniline	587, 455, 549, 499
"Aminomalachitegreen"	628, 586, 460, 420
Dimethyldiaminofuchsone	590, 624, 489, 545, 453, 420

The text is to be consulted for the conditions under which the different bands appear.

Correction to Part XVI, p. 236.—The correct reading for 2-2′-dioxyaurine is λ 495 broad, non-fluorescent. Its anhydride is 4″: hydroxy-resorcin-benzeine of λ 488 (narrow) with strong green fluorescence. Holmes and Scanlan (J. Amer. C.S., 1927, p. 1595) suggested (correctly) that λ 545 was unlikely, which led to this correction.

VELD-BURNING EXPERIMENTS AT IDA'S VALLEY, STELLENBOSCH.

By Margaret R. Levyns,
Lecturer in Botany, University of Cape Town.

(With ten Text-figures and Plates I–IV.)

Introduction.

A good deal has been written and said of late years in connection with the subject of veld-burning. The general attitude of the scientific world is well voiced in the final report of the Drought Investigation Commission, 1923, in which the practice of veld-burning is whole-heartedly condemned. Unfortunately the findings of such a commission have small effect on the farmers who indulge in the practice. Immediate results are of more value to them than problematical benefits in the future, and thus the farming community is loth to give up a habit in which they and their ancestors have indulged unless some definite proof of its evil effects can be demonstrated. It must be recognised that although a large number of farmers burn their veld simply because it is a well-established custom, yet there are others whose experience has led them to the view that under certain conditions burning may be beneficial. These latter naturally ask the scientist who is condemning the practice as a whole, on what evidence he is relying for the statements he makes. The truth must be confessed that apart from some general observations that have been made here and there in the country, and a few as yet incomplete experiments which have been carried out in the Transvaal (5, 6) and Natal (8), the subject has not received the attention it deserves. Detailed experimental work is necessary in order to gain an understanding of the many factors involved and the precise effect of each. For instance, at the present time over-grazing and burning are generally credited with being disastrous to the welfare of the country, and yet how little we know of the effect of each process individually! The two usually go hand in hand, and it is a matter of great difficulty to assess the relative importance of each in any given case. The need for a thorough investigation is emphasised by the diverse types of vegetation which characterise the different climatic zones in South Africa. Thus burning the scrub of the

south-west coastal belt presents entirely different problems from those arising when the grasslands of the High Veld are burnt. Although experiments on the grass veld have been initiated by Phillips working near Pretoria and Staples at Cedara in Natal, as far as the writer is aware there are no records of experimental work on this problem in the south-west.

The present investigation first suggested itself as a result of some general observations made by the author on the effects of burning on the vegetation of Signal Hill (4). This work was of necessity purely observational in character, and it was felt at the time that there was need for experimental work in which burning and grazing could be controlled by the investigator. At that time there seemed very little chance of securing a suitable piece of ground and the means with which to carry out the necessary experiments. In 1924, however, Mr. Malleson of Ida's Valley, Stellenbosch, was kind enough to offer a portion of his farm for experimental purposes, and that offer was eagerly accepted. I wish to take this opportunity of expressing my gratitude to Mr. Malleson for his generosity in giving up part of his farm and for the assistance which has been so willingly given throughout the progress of the work. I also wish to acknowledge my indebtedness to the Research Grant Board for a grant which has rendered the work possible.

Description of the Experimental Area.

Ida's Valley lies about two miles north-east of Stellenbosch and occupies a sheltered position at the foot of the mountains. The area chosen for these experiments lies in a secluded valley running roughly east and west, and possessing a fine-grained soil derived from granite rocks. The sides of the valley are densely clothed with vegetation, and it is a point of interest in connection with these experiments that this vegetation has remained untouched for at least sixteen years. The two sides of the valley are in marked contrast, due almost certainly to difference in aspect. The slope facing south has a luxuriant vegetation in which *Protea pulchella* and *Leucadendron lanigerum* are outstanding plants. The slope facing north is covered with dense Rhenosterveld, with the characteristic proteaceous members of the opposite slope scattered about here and there (Pl. I, fig. 1). In view of the fact that the author's previous observations on veld-burning had been made on Rhenosterveld it was considered desirable to select the same general type of vegetation for the more extended work contemplated. The slope with the northern aspect was therefore chosen.

The following meteorological notes are of interest in connection with the experiments to be described.

Altitude.—Readings with the aneroid barometer showed the valley to be approximately 400 feet above sea-level.

*Rainfall.**—Most of the rain falls during the winter months, and the summer is comparatively dry. The average rainfall for the years 1916 to 1926 inclusive is 26·92 inches per annum, distributed over the different months of the year, as shown below. However, there is considerable deviation from these average figures, as may be seen by consulting the maximum and minimum figures given.

TABLE I.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average for the years 1916 to 1927, inclusive .	0·95	0·53	0·44	1·72	3·58	5·95	4·09	3·27	2·36	1·91	1·49	0·63	26·92
Maximum for the same years . .	2·43	1·10	1·23	3·85	8·66	9·28	6·86	5·82	4·36	3·22	2·99	1·49	35·93
Minimum for the same years . .	0·0	0·0	0·01	0·64	0·62	1·40	2·55	0·45	0·56	0·76	0·22	0·0	19·91

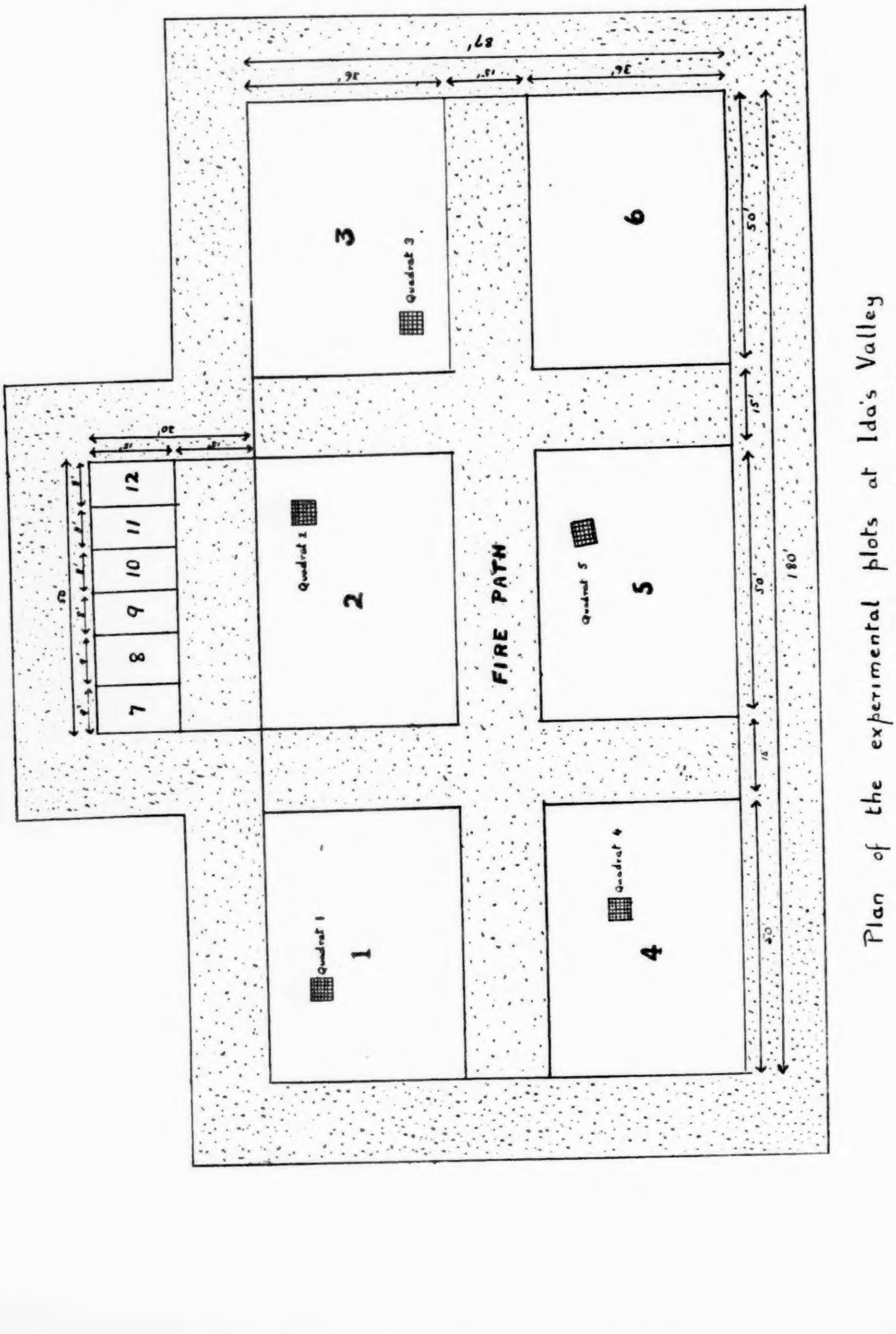
Temperature.—No actual figures are available but it seems clear that owing to the sheltered nature of the valley the winter temperatures at any rate are slightly higher than those in the immediate neighbourhood of Stellenbosch. For instance, on one or two occasions, the common lying between Ida's Valley and Stellenbosch was white with frost in the early morning, whereas no traces of frost were present on the experimental plots. The highest summer temperature recorded was 88° F. in the shade, but the author naturally did not select the hottest days for visits.

Winds.—The prevailing winds, south-east in summer and north-west in winter, are not felt with severity owing to the sheltered position of the valley.

SCHEME OF WORK AND DESCRIPTION OF THE UNTOUCHED VEGETATION ON THE EXPERIMENTAL AREA.

The work was started in December 1924, when the area selected was mapped out. The original plot surveyed was 180 feet by 87 feet (text-fig. 1). This was subdivided into six equal areas, each 50 feet by 36 feet, leaving fire-paths 15 feet wide between each plot (Pl. I, fig. 2). The work of fencing in the whole area and of clearing the fire-paths, as shown in the diagram, was completed towards the end of January. The small plots (7 to 12) at

* I am indebted to Mr. Malleson for the rainfall figures given in this paper.



TEXT-FIG. 1.—Plan of the experimental plots at Ida's Valley.

the top of the diagram were added about eighteen months later and therefore have no bearing on the initial stages of the experiments.

A necessary preliminary to a proper understanding of the changes that are brought about by interference in any plant community is a detailed knowledge of the plants composing that community under normal conditions, and the seasonal changes that occur. The following account, therefore, deals with the vegetation that covered the area at the beginning of the investigation.

In spite of the fact that from a distance the Rhenoster bush (*Elytropappus Rhinocerotis*) appeared to dominate the landscape, on a more careful examination it was at once obvious that a large number of different plants entered into the composition of the vegetation (Pl. II, fig. 3). In the accompanying list all the species seen on the area have been grouped into five classes as follows :—

(The plants in each section are arranged as far as is possible in order of relative abundance.)

(a) *Shrubs over 2 feet in height, the interlacing branches of which form the uppermost stratum.*

Elytropappus Rhinocerotis Less (a).*
Anthospermum aethiopicum L. (a).
Metalasia stricta Less (f).
Dodonaea thunbergiana E. and Z. (l. f).
Protea pulchella Andr. (o).
Leucadendron lanigerum Buek. (o).
Athanasia trifurcata L. (r).
Royena glabra L. (r).

(b) *Small shrubs, 2 feet and under, and other evergreen plants which occupy the ground in between the larger bushes.*

Erica imbricata. (Usually (f) but here and there (a).
Montinia acris L.f. (f).
Restio cuspidatus Th. (f).
Aspalathus divaricata Th. (o).
Aspalathus incurva Th. (o).
Bobartia spathacea Ker (o).
Erica globosa Andr. (o).
Helichrysum teretifolium Less (o).

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* (a) = abundant ; (f) = frequent ; (o) = occasional ; (r) = rare. The letter "l" prefixed to the symbol indicates that the distribution is local only.

Plan of the experimental plots at Ida's Valley

TEXT-FIG. 1.—Plan of the experimental plots at Ida's Valley.

Erica paniculata L. (o).
Indigofera incana Th. (r).
Chironia baccifera L. (r).
Mesembryanthemum gracile Haw. (r).
Corymbium nervosum Th. (r).
Adenandra serpyllacea Bartl. (r).

(c) *Plants with storage organs, spending part of the year below the ground level, usually less than 1 foot high, and occupying the open spaces between the evergreens.*

**Mohria caffrorum* Desv. (f).
Micranthus plantagineus Eckl. (f).
**Oxalis variabilis* Lindl. (f).
**Oxalis purpurea* Th. (f).
**Oxalis versicolor* L. (f).
Micranthus fistulosus (l. f).
Drosera pauciflora Banks (o).
Lapeyrousia corymbosa Ker (o).
Danthonia stricta Schrad. (o).
Hexaglottis longifolia Vent. (o).
Ehrharta capensis Th. (o).
Cyanella capensis L. (o).
Lachenalia orchioides Ait. (r).
Geissorhiza excisa Ker (r).
Geissorhiza secunda Ker (r).
Andropogon Nardus L. var. *marginatus* (r).
Koeleria cristata Pers. (r).
Hypoxis stellata L.f. (r).
Hypoxis sp. (r).
Albuca minor L. (r).
Ornithogalum hispidum Hornem (r)
Moraea papilionacea Ker (r).
Disperis capensis Swtz. (r).
Disa micrantha Bolus (r).
**Crassula septas* Th. (r).
Cyphia bulbosa Berg. (r).
Cyphia Phyteuma Willd. (r).
**Oxalis sericea* L.f. (r).
Satyrium sp. (r).
Watsonia punctata Ker (r).

* Flowering during the autumn and early winter months.

(d) *Small annuals occupying similar situations to those in Class* (c).

Vulpia bromoides S. F. Gray (o).
Aira caryophyllea L. (o).
Lasiochloa ciliaris Kunth (o).
Pelargonium grossularioides Ait. (o).
Sebaea aurea R. Br. (o).
Scirpus antarcticus L. (o).
Sebaea exacoides Schinz (r).
Zaluzianskya divaricata Walp. (r).
Diascia elongata Benth. (r).
Nemesia barbata Benth. (r).
Koeleria phleoides Pers. (r).
Briza maxima L. (r).
Briza minor L. (r).
Wahlenbergia cernua A. DC. (r).

(e) *Moss and lichen flora, occupying the surface of the soil here and there.*

Moss (undetermined, about 5 mm. high and not fruiting).
Cladonia sp.

The shrubs in class (*a*) form the uppermost stratum of the vegetation and in an area such as this, which has been free from the influence of grazing and burning for a large number of years, constitute a dense covering shading the plants of all other classes. Of the two abundant plants in this class the Rhenoster bush is of considerably greater importance than *Anthospermum aethiopicum* owing to the stiff, upright habit of the latter which renders it negligible as a shade-affording plant. The average height of the Rhenoster bush is about $3\frac{1}{2}$ feet, *Anthospermum aethiopicum* being rather shorter. The tallest plant (apart from *Dodonaea thunbergiana*, which is purely local in its distribution) is *Metalasia stricta*, which may reach a height of 6 feet, but owing to its scanty branching and straggling habit has no great ecological importance. Members of class (*b*) occupy the space in between the larger shrubs, and many of them in their turn shade the plants of the succeeding classes. The outstanding plant of this class is undoubtedly *Erica imbricata*, which is frequent throughout the area and here and there assumes a dominant rôle. In these local patches the Rhenoster bush is stunted and inconspicuous. The reason for the occurrence of such patches is obscure, and tests made to determine the water content and specific acidity of the soil gave similar results to those obtained with soil from other parts of the area. The phenomenon is analogous to that which may be noted on the slopes of the mountains round Stellenbosch and elsewhere, where *Anthospermum aethiopicum* (a reliable plant indicator of soil fertility) forms similar local patches.

Class (*c*), by far the largest class, comprises those plants which spend the hot summer months dormant below the surface of the soil. Though most of the plants are geophytes, the term is not strictly applicable to all members of this class, as some, notably the grasses, are better defined as hemicryptophytes. This class may be subdivided into two clearly defined sections according to the time of year at which the plants flower : (i) plants flowering about the time of the first rains, *i.e.* May to July ; and (ii) plants flowering in the latter part of the rainy season, *i.e.* August to October. No monocotyledons are to be found in the first class, various species of *Oxalis* and *Mohria caffrorum* being the characteristic plants. Class (*e*) is only in evidence during the winter months.

The foregoing list of plants may give the impression of much greater luxuriance than is actually the case. Classes (*a*) and (*b*) are well represented under normal conditions, but classes (*c*) and (*d*) are inconspicuous. This is due to the fact that, although a few poorly developed leaves of a large number appear, only a small percentage of the plants flower in any given year.

Before passing on to a discussion of the detailed results obtained on each plot, it will be a point of considerable interest in connection with some of the results obtained to give the approximate times of flowering and seed dispersal in the case of the principal shrubs on the area.

	Flowering period.	Period of seed dispersal.
Elytropappus Rhinocerotis .	May–June.	June–August.
Anthospermum aethiopicum .	July–October.	December–January.
Metalasia stricta . . .	April–June.	June–August.
Erica imbricata . . .	June–October.	December–January.
Dodonaea thunbergiana . .	September–October.	December.

From the table it is clear that the plants fall into two classes : (i) those which shed their seed during the winter months ; and (ii) those which shed their seeds during the summer months.

Description of the Experimental Plots.

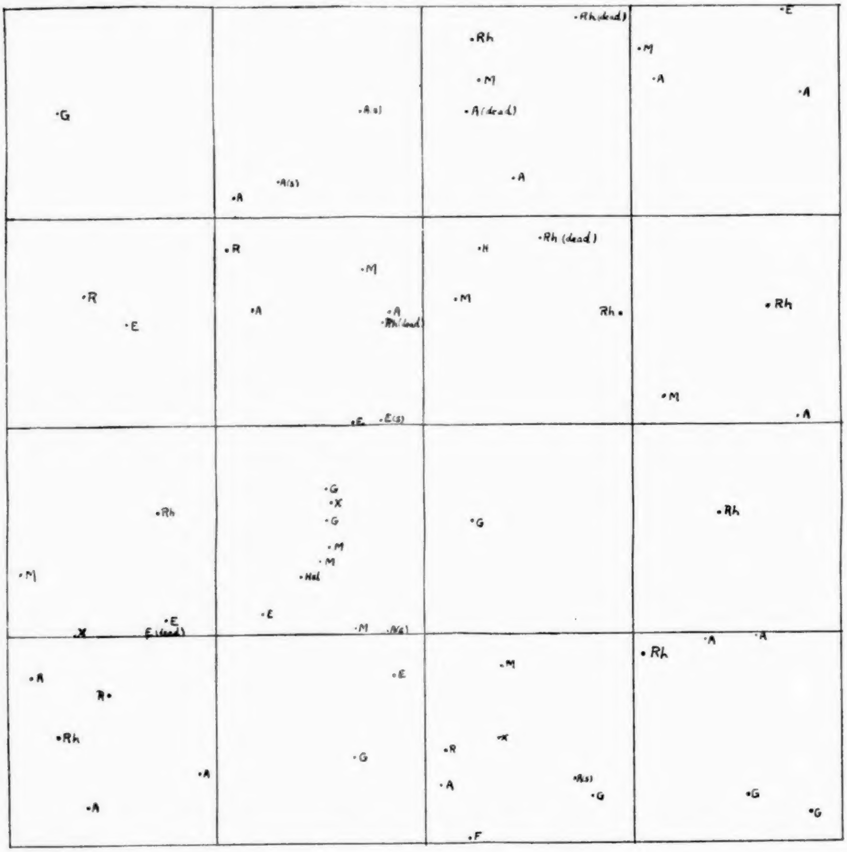
With the exception of Plot 2, the plots showed a fairly uniform slope from top to bottom of approximately 25 degrees. Plot 2 was somewhat less steep in its upper fifth and considerably steeper in its lower four-fifths. A rocky outcrop near the centre of this plot distinguished it from the remainder. The vegetation of Plots 1, 2, and 4, and most of 5 and 6, was typical of the area as a whole. Plot 3 showed a rather greater number of

plants of *Metalasia stricta* than the others, and its north-eastern corner was occupied by a patch dominated by *Erica imbricata*. Similar patches were found on Plots 5 and 6, though in these the patches were of much smaller extent, and in each case at the bottom of the plot.

Before interfering with the vegetation in any way, a careful survey of each plot was made. In order to do this, the species on each plot were listed together with their relative frequencies. With the exception of Plot 6, permanent quadrats, each 4 feet square, were laid down on each, iron pegs being used for marking the corners. Careful vegetation maps of each quadrat were made early in February (text-figs. 2, 3, 4). The following list prepared from the maps will give an idea of the principal constituents of the plant population on the five quadrats :—

	Plot 1. Burned.	Plot 2. Burned.	Plot 3. Burned.	Plot 4. Cleared.	Plot 5. Control.
Elytropappus Rhinocerotis—					
Old plants	9	9	2	39	12
Seedlings or very young plants	0	0	0	0	0
Anthospermum aethiopicum—					
Old plants	14	8	0	11	14
Seedlings or very young plants	4	5	1	0	12
Erica imbricata—					
Old plants	6	2	17	17	12
Seedlings or very young plants	1	0	1	3	3
Metalasia stricta—					
Old plants	0	5	0	4	1
Seedlings or very young plants	0	0	0	0	0
Dodonaea thunbergiana—					
Old plants	0	2	0	0	0
Seedlings or very young plants	0	0	0	0	0
Montinia acris . . .	9	0	0	0	6

Certain interesting features may be noticed here. The Rhenoster bush, *Metalasia stricta* and *Dodonaea thunbergiana* showed no seedlings or young plants, while *Anthospermum aethiopicum* and *Erica imbricata* did so. In order to see how far these facts applied to the area as a whole, the plots were re-examined from the point of view of their seedling population. A few young plants of *Dodonaea thunbergiana* were found, but for the rest

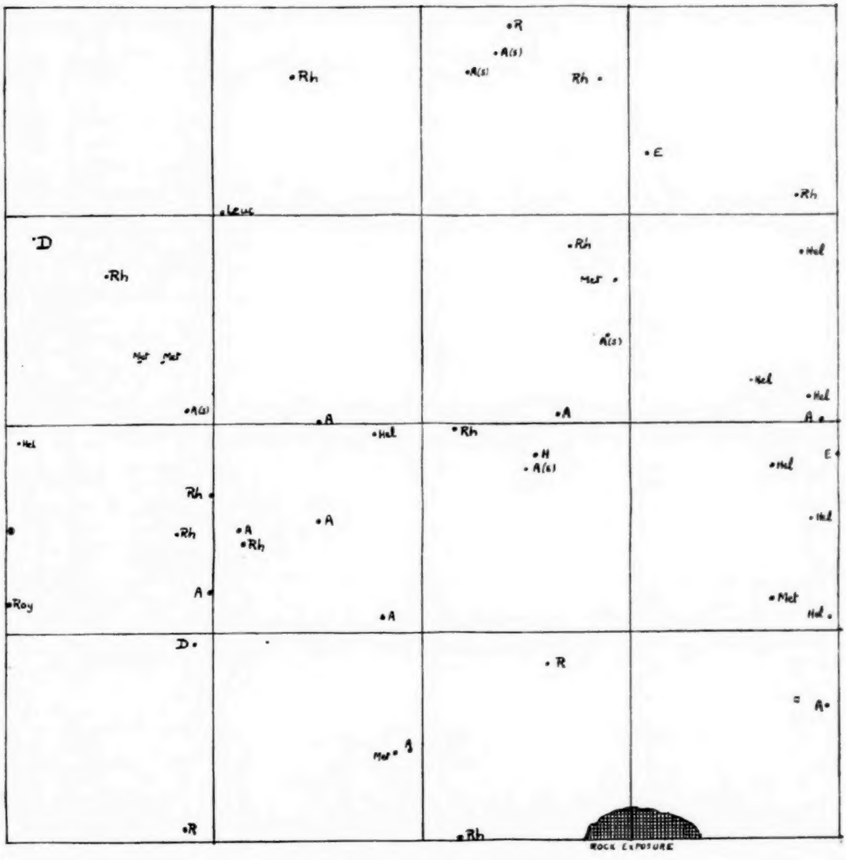


PLOT 1 FEBRUARY 1925

Text-fig. 2.

See p. 92 for list of symbols used in this and the following maps of the quadrats.

the results given by the quadrats held good. A particularly large number of plants of the Rhenoster bush were recorded on the quadrat on Plot 4. Most of these were much below the average in size, though they were certainly not young plants. This variation in the constitution of the plant population was purely local, the plot as a whole showing a normal number of plants of the Rhenoster bush.



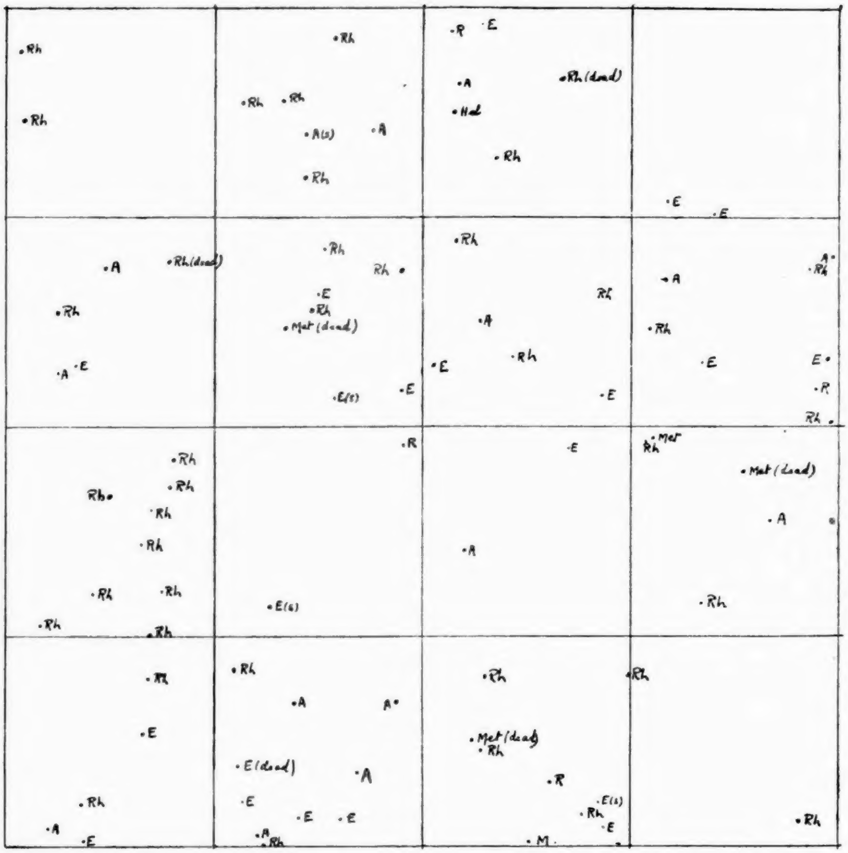
PLOT 2 FEBRUARY 1925

TEXT-FIG. 3.

Further procedure with the plots was intended to be as follows :—

Plots 1, 2, and 3	.	To be burnt.
Plot 4 . .	.	To be cleared of bush, but the soil left undisturbed.
,, 5 . .	.	To be left untouched as a control.
,, 6 . .	.	The bush to be ploughed in.

The latter part of the summer of 1925 was very dry, and, owing to the



PLOT 4 FEBRUARY 1925

TEXT-FIG. 4.

inflammable nature of the Rhenoster bush and the dense vegetation covering the farm in this part, it was not considered advisable to burn until the first good shower of rain had fallen. Thus burning did not take place until the 20th April, when Plots 1, 2, and 3 were burnt. Plot 4 was cleared about the same time, but Plot 6 had to be left until sufficiently heavy rains had fallen to soften the ground for ploughing. This unfortunately could not be done till June, by which time the other plots were showing definite

growth, and the results could not therefore be regarded as strictly comparable. For this reason, and also because the study of the five other plots occupied all available time, no detailed work on Plot 6 was carried out.

Changes on the Plots after Burning, Clearing, etc.

Owing to an inflammable substance in the twigs of the Rhenoster bush, the plants burn rapidly even when green. The process of burning the plots was completed in a few minutes, but the ground, together with the ash resultant from the fire, retained considerable heat for well over an hour. The main stems of the Rhenoster bush do not burn away but remain *in situ* as charred sticks (Pl. II, fig. 4). Plants of *Erica imbricata*, on the other hand, burn up completely. The foreground in Pl. III, fig. 5, shows an area on Plot 3 on which *Erica imbricata* was abundant before the fire.

May 1925.—A visit about three weeks after burning and clearing showed very little change on the plots. The Blesmol (*Georychus capensis*) had been very active, throwing up mounds on Plots 1 and 2. On Plots 1, 2, and 3 *Bobartia spathacea* and a member of the Cyperaceae, possibly *Ficinia bracteata*, were showing rapid intercalary growth.

July and August 1925.—By July growth had taken place on all the plots, though this was much less marked on the control plot than on the others. The five quadrats were mapped once more and the information obtained has been incorporated in the following table :—

	Plot 1. Burned.	Plot 2. Burned.	Plot 3. Burned.	Plot 4. Cleared.	Plot 5. Control.
Monocotyledons (including grasses)	96	84	110	287	59
Oxalis variabilis . . .	31	6	7	0	5
O. versicolor	15	6	23	17	14
O. purpurea	50	17	45	23	14
O. sericea	0	25	0	0	0
Total for all species of *Oxalis*	96	54	75	40	33
Drosera pauciflora . . .	4	0	0	8	2
Mohria caffrorum . . .	1	24	0	67	67
Pelargonium seedlings . .	14	83	25	1	0

The various species of Oxalis, most of which were still in flower, formed a conspicuous feature of Plots 1, 2, and 3. On Plot 4, though the plants

were fairly well developed few had flowered, while on Plot 5 most of the plants were small and stunted and flowers were rare. The obvious deduction is that burning and not merely the screening action of the bushes is responsible for the increased vigour shown by members of this genus. The presence of numerous seedlings of Pelargonium was a surprising feature. In the preliminary survey plants of this genus had been confined to a few miserable plants of *P. grossularioides*, and the seedlings now apparent later turned out to belong almost entirely to two other species, viz. *P. tabulare* and *P. myrrhifolium* (Pl. III, fig. 6), neither of which had been seen up to this point. The figures show very clearly that burning was responsible for their presence. Confirmation of this fact was obtained from their appearance in large numbers in the fire-paths on the spots where debris from the cleared areas had been burnt. Elsewhere in the fire-paths they were absent. The moss and lichen flora to which reference has been made earlier in the paper was confined to Plot 5. It is of some interest to note that on Plot 2, which had a steeper slope than the rest, a considerable amount of soil erosion had taken place, laying bare the underlying rock.

Bearing in mind the fact that for grazing purposes leaves of the petaloid monocotyledons are either useless or harmful, a series of counts was made about this time to determine the relative numbers of such plants as compared with members of the Gramineae and Cyperaceae. Other plants were counted at the same time as a matter of interest, and they are included in the Tables given below. A hollow square, with a side measuring 2 feet, was placed on a number of representative samples on each plot. The following are the results obtained (p. 75).

An important fact which is not brought out by these figures is that whereas Plot 1 shows an average number of grasses higher than Plot 4, in reality the grasses on Plot 4 were much more conspicuous owing to their large size. The numbers on Plot 1 were chiefly made up of several small grasses and members of the Cyperaceae, such as *Lasiochloa ciliaris*, *Vulpia bromoides*, *Aira caryophyllea* and *Ficinia* sp., whereas the large *Ehrharta capensis* was a characteristic grass on Plot 4 and dominated the new growth.

During August screens were erected on Plots 1 and 4 in order to assess the importance of shading to the growth of the various seedlings which were present on these plots. Each shelter consisted of a roof of chicken wire, 6 feet by 3 feet, supported by six poles each 2 feet high. The roof was thatched with branches of the Rhenoster bush until the readings given with a Watkin's Bee Meter corresponded with those obtained beneath living bushes.

September 1925.—During this month and the next the outstanding

	"Grasses." *	Pet. Monocots.	Oxalis.	*Mohria caffrorum.*
Plot 1 (burned)—				
Sample 1 . . .	137	26	13	0
,, 2 . . .	0	28	3	0
,, 3 . . .	70	30	38	0
,, 4 . . .	57	76	12	0
Average . . .	66	40	16	0
Plot 2 (burned)—				
Sample 1 . . .	14	62	18	0
,, 2 . . .	27	28	18	0
,, 3 . . .	29	46	8	14
Average . . .	33	45	15	5
Plot 3 (burned)—				
Sample 1 . . .	8	25	35	1
,, 2 . . .	12	21	52	0
,, 3 . . .	4	19	35	0
Average . . .	8	22	41	·3
Plot 4 (cleared)—				
Sample 1 . . .	88	8	36	4
,, 2 . . .	64	24	9	4
,, 3 . . .	55	21	28	10
,, 4 . . .	66	26	12	3
,, 5 . . .	49	27	17	7
Average . . .	64	21	20	6

feature on the burnt plots was the vigorous growth and abundance of flowers among the geophytic monocotyledons. The cleared plot, No. 4, showed only two species in flower, and their numbers were so small that burning, apart from the removal of the covering bush incidental to a fire, must be regarded as the factor inducing this burst of vigour. The control plot, No. 5, showed a few rather poor specimens of some of the species so well represented on the burnt plots (Table II).

* Used here, but not elsewhere in the paper, to include members of the Cyperaceae which at this early stage were difficult to distinguish from true grasses.

TABLE II.—*Table of Species in Flower.*

	Burnt Plots (1, 2, and 3).	Cleared Plot (4).	Control Plot (5).
September. GEOPHYTES .	*Drosera pauciflora* (f). *Geissorhiza excisa* (f). *Lachenalia orchioides* (f). *Hypoxis* sp. (f). *Moraea papilionacea* (o). *Geissorhiza secunda* (o). *Disperis capensis* (white variety) (o). *Disperis villosa* (r). *Pterygodium alatum* (r).	*Drosera pauciflora* (o). *Disperis villosa* (r).	*Drosera pauciflora* (o). *Hypoxis* sp. (o). *Moraea papilionacea* (r). *Geissorhiza excisa* (r). *Disperis capensis* (r).
OTHER PLANTS .	*Diascia elongata* (o). *Zaluzianskya divaricata* (o). *Pelargonium tabulare* (o).		
October. GEOPHYTES .	*Lapeyrousia corymbosa* (f). *Cyanella capensis* (o). *Albuca minor* (r). *Disa micrantha* (r).	*Lapeyrousia corymbosa* (o).	*Lapeyrousia corymbosa* (o).
ANNUALS .	*Aira caryophyllea* (f). *Vulpia bromoides* (f). *Wahlenbergia cernua* (f). *Sebaea exacoides* (o). *Sebaea aurea* (o). *Anagallis arvensis* (o). *Pelargonium grossularioides* (o).	*Vulpia bromoides* (f). *Lasiochloa ciliaris* (f). *Aira caryophyllea* (o). *Briza maxima* (o). *Briza minor* (o). *Anagallis arvensis* (o). *Sebaea exacoides* (o). *Wahlenbergia cernua* (o). *Nemesia barbata* (r). *Koeleria phleoides* (r).	*Sebaea aurea* (o).
OTHER PLANTS .	*Pelargonium tabulare* (f). *Bobartia spathacea* (o). *Montinia acris* (o). *Ehrharta capensis* (o) (but frequent in part of Plot 1). *Indigofera incana* (o). *Aspalathus divaricata* (o). *Corymbium nervosum* (white variety) (r).	*Ehrharta capensis* (f). *Koeleria cristata* (o).	*Erica imbricata* (l. a). *Anthospermum aethiopicum* (a). *Erica globosa* (o). *Helichrysum teretifolium* (o). *Montinia acris* (o).
December. GEOPHYTES .	*Micranthus plantagineus* (a). *Ornithogalum hirsutum* (o). *Hexaglottis longifolia* (o). *Micranthus fistulosus* (o). *Watsonia punctata* (r).	*Micranthus plantagineus* (f). *Ornithogalum hirsutum* (o).	*Micranthus plantagineus* (o).
OTHER PLANTS .	*Danthonia stricta* (f). *Pelargonium tabulare* (f). *Pelargonium myrrhifolium* (o). *Bobartia spathacea* (o). *Corymbium nervosum* (o). *Aspalathus divaricata* (o). *Aspalathus incurva* (o). *Andropogon Nardus* var. *marginatus* (r).	*Danthonia stricta* (o). *Crassula sphaeritis* (r).	None.

October 1925.—Similar results to those of September were noted, but with some marked differences. The species in flower were different from those seen previously, grasses were beginning to flower and annuals were conspicuous in all but the control plot. Under the light screens vigorous growth of grasses and other monocotyledons was a definite feature.

December 1925.—A high rainfall was experienced during November and consequently the plots were still green in December. Most of the grasses had finished flowering, but several other plants were in flower as will be seen from the accompanying table.

It will be noticed that no annuals appear on the list. The monocotyledon flora covered by the light shelters on Plots 1 and 4 was greener and more luxuriant than elsewhere, but various seedlings, which by this time could be recognised, were faring badly. The shaded seedlings of the Rhenoster bush and *Metalasia stricta* on Plot 1 were stunted and weak in comparison with those growing in the open. Neither of these seedlings was represented under the shelter on Plot 4. Seedlings of *Anthospermum aethiopicum* occurred under both shelters, and they too were obviously suffering from the shaded conditions under which they were growing.

The plots had been fenced in with strands of barbed wire at the beginning of the experiments in order to prevent them from being grazed. However, during December the fence proved totally inadequate in this respect, as on different occasions buck, a hare, and several tortoises were caught at work eating down the young growth. Grasses were specially selected, and it was found that the young tips of *Anthospermum aethiopicum* were popular with buck. Seedlings of the same plant were being devoured by the tortoises, which, however, were never seen to touch seedlings of the Rhenoster bush. In view of this unforeseen complication and the impracticability of placing a high fence of a suitable nature round the whole area, wire cages were made of 1-inch mesh chicken-wire and placed over the quadrats on all five plots.

As has been shown in a previous paper (4), bushes, with few exceptions, react to the process of burning in one of two sharply defined ways : (i) they spring up from parts which lie below the soil level, or (ii) they are killed off completely and rely on seed for further development.

Bushes of Plots 1, 2, *and* 3 *putting up new shoots from the ground.*

Montinia acris.
Aspalathus divaricata.
Aspalathus incurva.
Leucadendron lanigerum.
Dodonaea thunbergiana.
Royena glabra.

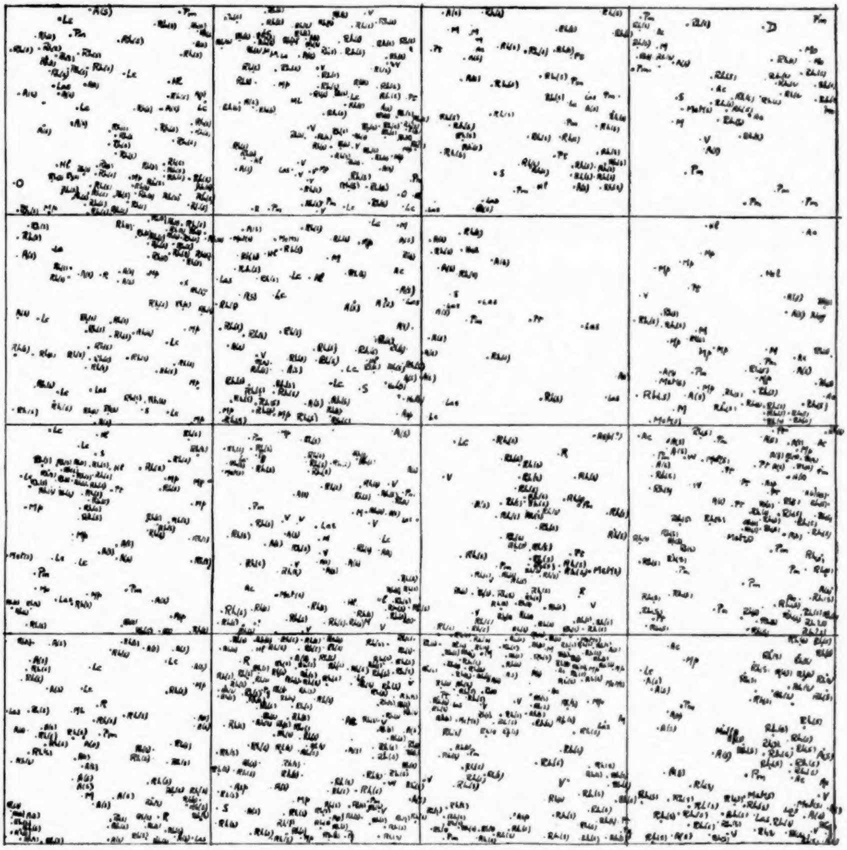
Bushes of Plots 1, 2, *and* 3 *relying on seed for development.*

Elytropappus Rhinocerotis.
Anthospermum aethiopicum.
Metalasia stricta.
Erica imbricata.
Dodonaea thunbergiana.

It will be noted that the plants of the second group are of greater ecological importance than those of the first.

During December the five quadrats were re-mapped (text-figs. 5, 6, 7). The following table has been compiled from these quadrats :—

	Plot 1. Burned.	Plot 2. Burned.	Plot 3. Burned.	Plot 4. Cleared.	Plot 5. Control.
Elytropappus Rhinocerotis— Seedlings	694	32	53	11	0
Anthospermum aethiopicum— Seedlings	125	69	48	107	50
Erica imbricata— Seedlings	0	0	52	5	8
Metalasia stricta— Seedlings	14	7	18	0	0
Dodonaea thunbergiana— Seedlings	1	18	3	5	0
Pelargonium myrrhifolium— Seedlings plants . . .	37	65	22	0	1
Pelargonium tabulare— Seedlings plants . . .	11	82	9	0	0
Pelargonium grossularioides— Seedling plants . . .	4	0	0	0	2
Senecio pubigerus— Seedlings	6	3	5	3	0
Petaloid Monocotyledons .	67	35	87	56	39
Grasses	63	59	5	198	1
Cyperaceae and Restiaceae .	6	3	6	7	11
Montinia acris . . .	15	3	0	1	7



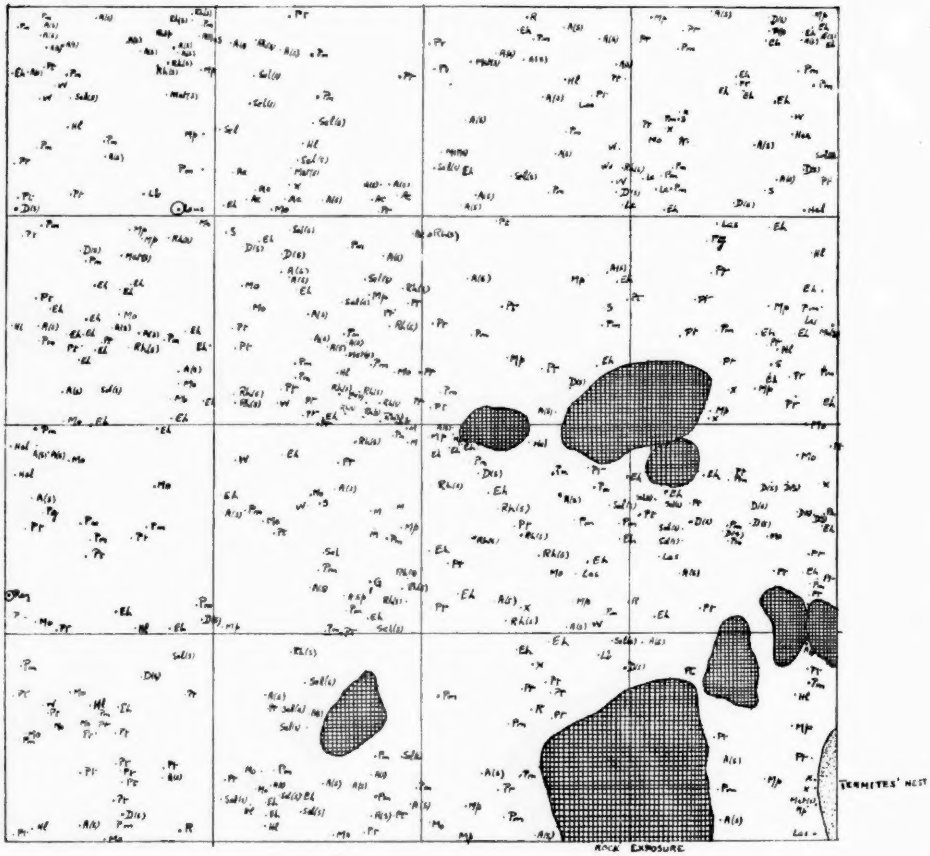
PLOT 1. DECEMBER 1925

TEXT-FIG. 5.

From a study of the quadrats and this list the seedlings can be grouped into distinct classes according to their behaviour.

(a) *Seedlings which are almost entirely confined to burnt areas.*

Elytropappus Rhinocerotis.
Metalasia stricta.
Pelargonium myrrhifolium.
Pelargonium tabulare.



PLOT 2. DECEMBER 1925

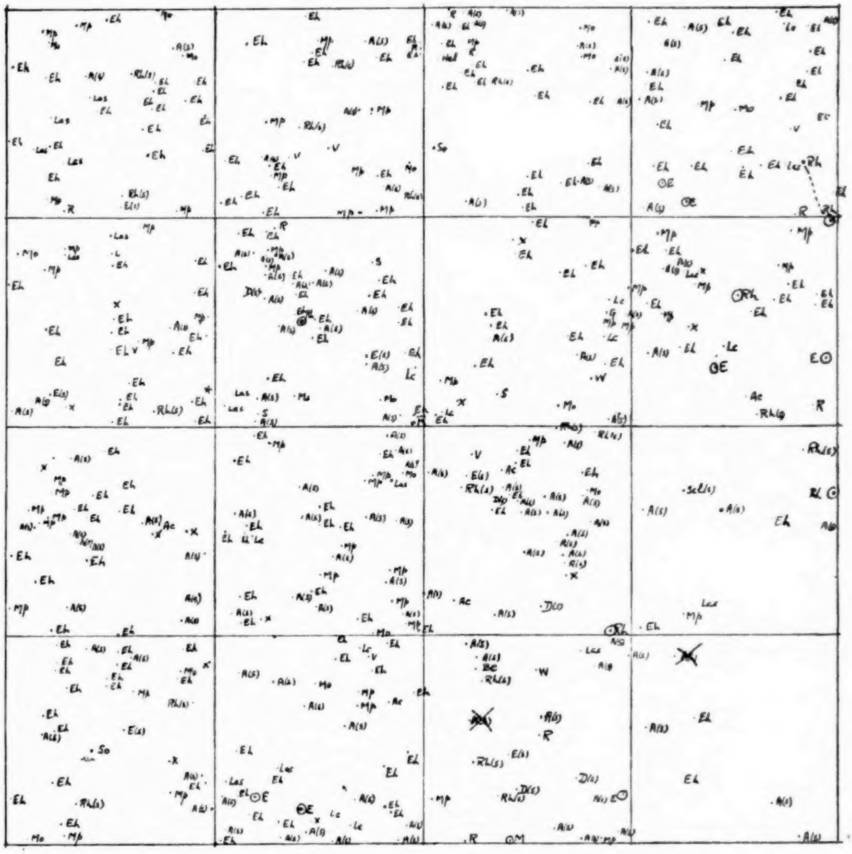
TEXT-FIG. 6.

(b) *Seedlings which prefer open places but with no marked preference for either the burnt or cleared areas.*

Senecio pubigerus.
Dodonaea thunbergiana.

(c) *Seedlings showing no preference.*

Anthospermum aethiopicum.
Erica imbricata.



PLOT 4 DECEMBER 1925

TEXT-FIG. 7.

The seedlings of *Erica imbricata* were extremely minute and difficult to recognise. A year later well-developed young plants were present on all the quadrats, and presumably these had been there in 1925 but, owing to their extremely small size, overlooked.

Progress in 1926.—The early months of the year were dry and the plots showed little change. During February *Mesembrianthemum gracile, Athanasia trifurcata,* and *Aspalathus divaricata* were found in flower. In

May the various species of Oxalis noted the previous year were once more in flower, though flowers were less abundant than on the previous year. The light shelters on Plots 1 and 4 made no apparent difference to these plants, as they flowered quite freely in the shade. The difference between the various seedlings growing under the shelters and those growing in the open was more marked then before.

The quadrats were not mapped during the winter months, but it was noticed in August that still further soil erosion had taken place on Quadrat 2.

The Spring flowers were neither as showy nor as numerous as on the previous year, though most of the same species were present. On the burnt plots, in addition to the species listed in 1925, the following weie noted :—

Polygala bracteolata.
Brizopyrum capense.
Thesium strictum.

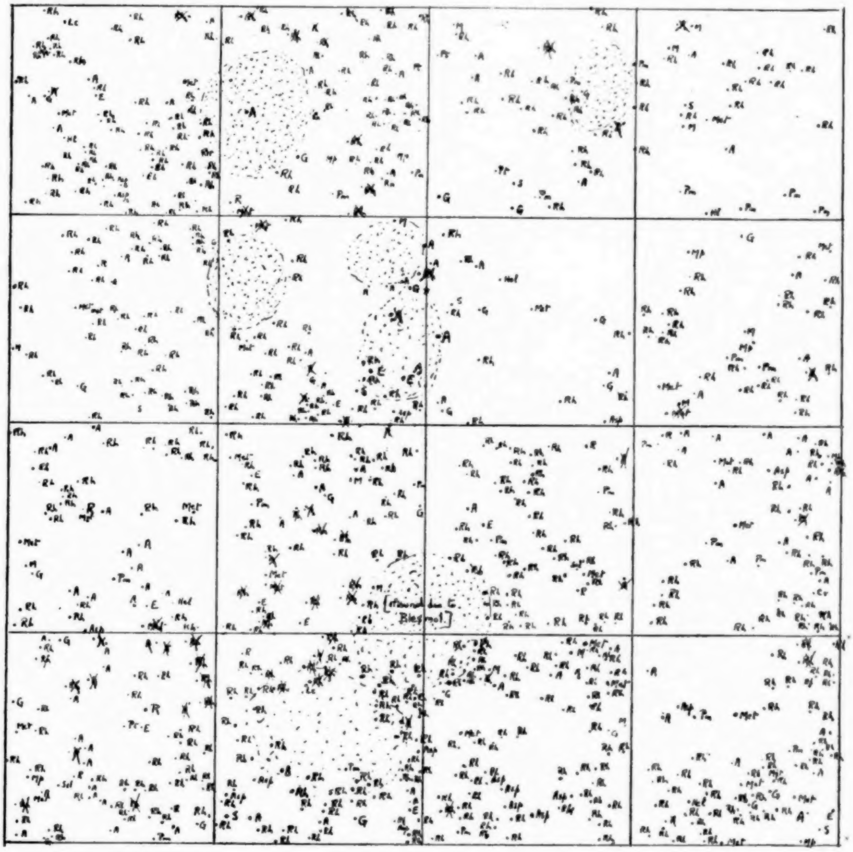
Plot 4 showed a much more closed type of plant community than that on the burnt plots, grasses and plants of *Anthospermum aethiopicum* being the most conspicuous members (Pl. IV, figs. 7 and 8).

October and November were much drier in 1926 than in the previous year, and this was reflected in the plants of the late Spring period, which were brown and dry early in December. A few plants not listed the previous year were seen in flower on the burnt areas.

Helichrysum cymosum.
Crassula sphaeritis.
Borbonia cordata.
Aspalathus incurva.

The five quadrats were mapped once more (text-figs. 8, 9). The following table has been made up from the information obtained from the quadrats :—

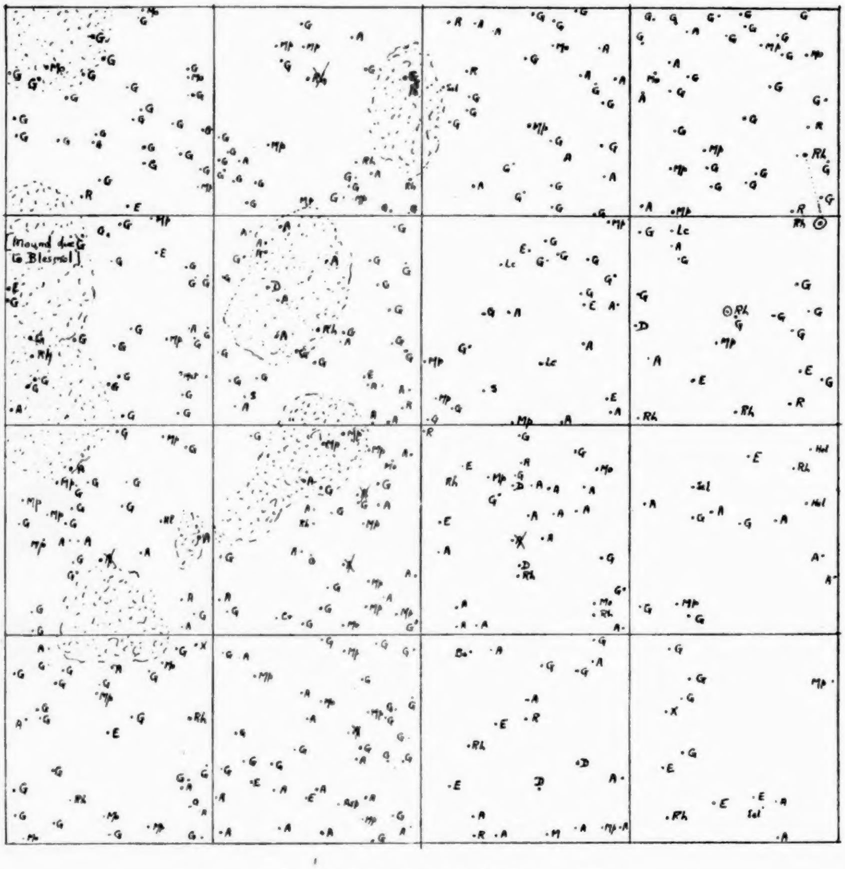
	Plot 1. Burned.	Plot 2. Burned.	Plot 3. Burned.	Plot 4. Cleared.	Plot 5. Control.
Elytropappus Rhinocerotis .	569	15	62	15	9
Anthospermum aethiopicum .	87	63	23	97	45
Metalasia stricta . . .	27	9	13	1	1
Erica imbricata . . .	11	1	343	17	15
Senecio pubigerus . . .	7	6	5	2	0
Dodonaea thunbergiana . .	0	18	4	6	0
? *Selago* sp.	0	24	2	3	0
Grasses	23	65	8	215	5



PLOT 1 DECEMBER 1926

TEXT-FIG. 8.

The leaves of the geophytic monocotyledons were so dry that they were not listed. It was impossible to distinguish small plants derived from seedlings of 1925 from seedlings of 1926. Therefore no distinction was made between young and old plants as in the previous seasonal lists. Thus in the case of the Rhenoster bush, the nine plants listed on Plot 5 were all old, and five of the fifteen on Plot 4 were derived from old plants whose stumps had sprouted. A comparison of the position of any given plant in



PLOT 4 DECEMBER 1926

TEXT-FIG. 9.

the quadrat maps will make its past history clear. The outstanding features of the list are (i) the enormous number of young *Erica* seedlings on Quadrat 3 (this was the site of a number of *Erica* plants before burning), (ii) the low mortality among Rhenoster seedlings during the year, and (iii) the large number of grasses on Quadrat 4.

Throughout the period of these investigations, but especially in the second year, the Blesmol was busily engaged in throwing up mounds on

all the plots on which the vegetation had been disturbed. A certain amount of activity occurred on the control plot, but was much less marked than on the others. This animal is well known to farmers and gardeners owing to its habit of feeding on bulbs and corms, and its presence may account, at any rate to some extent, for the decrease in the number of plants with storage organs of this type in the second year. A comparison of four maps made of Quadrat 2 at different times reveals another part played by the Blesmol. The first three maps showed progressive denudation of the area (two of these maps are represented in text-figs. 3 and 6), whereas on the fourth map much of the exposed rock had been covered over by earth thrown up by the animal.

The results of the work conducted in 1925 showed that the seedlings of the Rhenoster bush were definitely favoured by burning, and further information as to the factors at work in producing the observed results was clearly desirable. With this end in view a fresh area 50 feet by 30 feet was fenced in. This was subdivided into six plots, leaving a fire-path 15 feet wide, as shown in the diagram (text-fig. 1).

Owing to various circumstances, these new plots were not completed till the beginning of June 1926. They were then subjected to the following treatment, after which fresh Rhenoster seeds were scattered on all :—

Plot 7.—All the bush was burnt.

Plot 8.—After clearing the plot, the ash obtained from bush burnt on Plot 9 was sprinkled over an area 2 feet by 6 feet, from which the top inch of soil had been removed.

Plot 9.—After clearing the plot, a sheet of iron 2 feet by 6 feet was placed over soil from which the top inch had been removed. Rhenoster bushes were then placed on top of the iron and burnt so as to heat the soil below. No ash was allowed on this plot. At the first attempt to carry out the experiment the ground was merely cleared and the soil not disturbed, but owing to the heat engendered by the fire all the small sticks and other organic substances lying on top of the soil caught fire. It therefore became necessary to remove the upper layer of soil in order to avoid the formation of appreciable quantities of ash.

Plot 10.—This plot was cleared but nothing further done.

Plot 11.—This plot was cleared and 2 lbs. of bone meal scattered.

Plot 12.—This plot was cleared and 2 lbs. of superphosphate scattered.

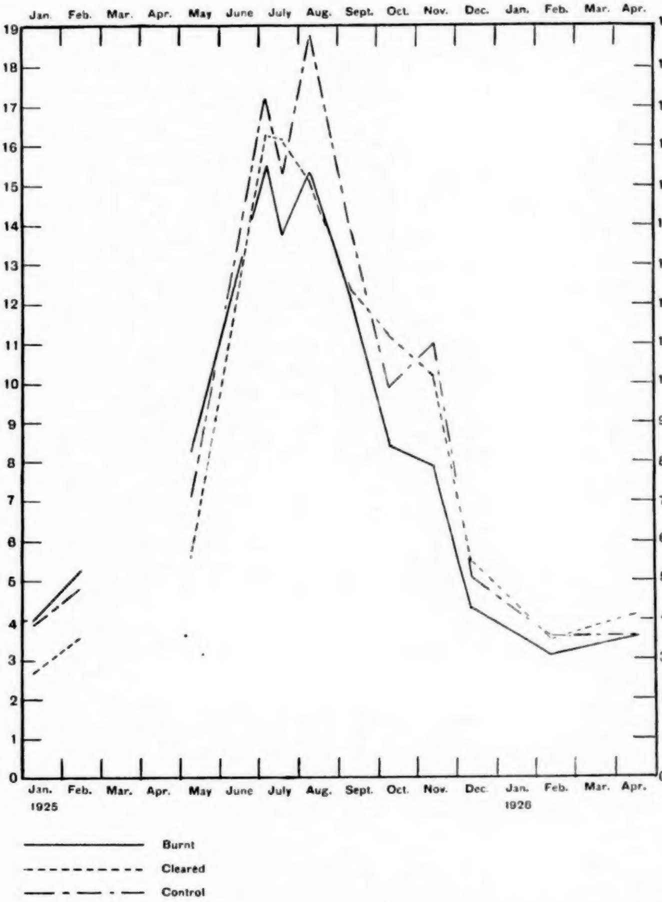
It was hoped that interesting information as to the behaviour of the Rhenoster seed would be obtained from these experiments. Unfortunately they were vitiated by an unforeseen factor. Shortly after starting these experiments it was found as a result of some germination studies conducted at the University of Cape Town that the Rhenoster seed is immature when

shed and shows a very low percentage germination, but if kept a year germinates well. The results of this investigation are being published in a series of papers, the first of which has just appeared (2). The bearing of these results on the experiments under discussion is obvious. On Plot 7, owing to the early winter rains having fallen some weeks previously, germination must have started before the plot was burnt. As newly-shed seed was sprinkled after burning, the fact that very few Rhenoster seedlings have appeared on the plot needs no further explanation. On Plots 8 and 9 the old Rhenoster seed was removed with the upper layer of soil, with the same results as in the case of Plot 7. Insufficient time has elapsed as yet to obtain results from the remaining plots.

On Plots 7, 8, and 9 *Pelargonium* seedlings were abundant, as they had been previously on Plots 1, 2, and 3, and their presence raises the question of their origin. As the seeds are shed during the early summer months, the arrival of seed in quantity after the plots had been treated was most unlikely. Further, as the seedlings appeared on Plots 8 and 9, they were presumably buried more than 1 inch below the surface of the soil. The *Pelargonium* fruit, as is well known, has the requisite mechanism for boring its way into the ground, but in view of the fact that in summer the surface of the ground is extremely hard, the feat is a most surprising one. *Anthospermum aethiopicum*, the seed of which is also shed in summer, affords a second problem of the same kind, as it appeared on Plots 7, 8, and 9.

Water Content of the Soil.

Throughout the progress of the investigation determinations were made of the water content of the soil, samples being taken from one of the burnt plots (Plot 1), the cleared plot, and the control plot. The method adopted was as follows: Samples of soil from each plot were collected from 6 inches below the surface, and placed in aluminium jars which were covered with tightly fitting lids. The next day 10 grammes of soil from each sample were weighed out and exposed to the air for two or three days. As soon as they ceased to lose weight they were weighed, and then placed in an oven at a temperature of 95° to 98° C. overnight. After cooling in a desiccator they were weighed once more and the further loss recorded. From this the loss of water calculated as a percentage of the dry weight was ascertained. The readings thus obtained for 1925 are shown in text-fig. 10. The presence of the Blesmol, especially during 1926, made this section of the work rather difficult to carry out. For instance, on one occasion the water content given for a particular sample was so low that it was thought advisable to take a fresh sample. On examining the hole from which the first one had been obtained it was found that a burrow ran immediately below it, which



TEXT-FIG. 10.—Chart showing the water content of the soil on Plots 1, 4, and 5 during the year 1925 and part of 1926. The break in the lines indicates the period at which Plot 1 was burnt and Plot 4 was cleared. The soil moisture is given as a percentage of the dry weight in each case. Readings were taken at approximately monthly intervals and the points thus obtained have been joined.

accounted for the drying out of that particular area. It will be noticed that the readings for May 1925, immediately after burning had taken place, show the burnt plot with the highest water content, but all other readings for the same year show the burnt area with a consistently lower water

content than the control plot. In view of the small size of the plots, these results should not be taken as anything more than suggestive.

Tests for Soil Acidity.

At the beginning of the investigation a rough test for carbonates was applied to soil from different parts of the area. This test consisted in moistening about 6 grammes of soil with 10 c.c. of concentrated HCl. In all cases a faint but perceptible effervescence took place, indicating soil of a neutral type. In January 1926 more delicate tests were applied, soil being collected from a burnt plot, the cleared plot, and the control plot. In the latter case two samples were taken, one from the Rhenoster-covered area and another from the small patch in which *Erica imbricata* was a conspicuous feature. A series of tests with soil indicators, those recommended by Dr. E. T. Wherry (9) being used, were made, with the result that in all cases a PH value=7 was obtained. The soil throughout the area was therefore neutral in character.

Soil Temperatures.

A few readings of the soil temperatures on the plots were made in 1926. They gave the following results, all readings being made 6 inches below the surface of the soil :—

Date.	Temperature of air.	Plot 1.	Plot 4.	Plot 5.
5th Jan. . .	27·0° C.	26·5° C.	26·4° C.	21·6° C.
26th March .	31·2° C.	28·1° C.	30·0° C.	24·6° C.
27th May . .	22·5° C.	14·8° C.	14·8° C.	14·1° C.
6th August .	18·0° C.	10·0° C.	10·0° C.	10·0° C.

Discussion.

There is much evidence to show that Rhenosterveld has encroached on various other plants communities within historic times in South Africa, and it is a commonplace that the areas over which it has spread have depreciated largely in value. This is specially unfortunate in view of the fact that the Rhenoster bush shows a decided preference for fine-grained soils, such as those derived from the Bokkeveld Series, which are extremely fertile. On the somewhat sterile sands of the Table Mountain Series it never attains its maximum development. The problem of the Rhenoster

bush is thus one of considerable economic importance, and it is therefore desirable to discuss the bearing of the results given in the foregoing account on the general problem.

The investigation at Ida's Valley shows clearly that Rhenosterveld is not a climax community but is a stage in succession. The evidence on which this statement is based is as follows : On Rhenosterveld which has remained untouched for at least sixteen years all the Rhenoster bushes are old and dead plants are of frequent occurrence. Although seed is produced in abundance, seedlings are unable to establish themselves in the shade of the old bushes, whereas seedlings of various other plants are able to do so. This points to the gradual disappearance of the Rhenoster bush and the consequent development of some other plant community. It has been pointed out in an earlier part of this paper that the side of the valley opposite to that on which the experiments have been carried out is covered by dense scrub in which proteaceous elements are conspicuous. The same plants are present scattered here and there amongst the Rhenoster bushes on the slope investigated, and at first sight it might appear that similar proteaceous scrub would be the next stage in succession. However, there is no evidence in support of this. *Protea pulchella* and *Leucadendron lanigerum*, both of which are represented on the experimental area, show no signs of reproducing themselves among the Rhenoster bushes. On the other hand, *Erica imbricata* and *Anthospermum aethiopicum*, both of them characteristic plants of the Rhenosterveld at Ida's Valley, reproduce themselves successfully under the existing conditions. The fact that in small areas in the Rhenosterveld *Erica imbricata* has succeeded in establishing itself, to the partial exclusion of the Rhenoster bush, may be significant. One thing, however, is certain, and that is that under unaltered conditions successional change must be extremely slow, and therefore leaving Rhenosterveld untouched in the hopes of veld regeneration is not a practical measure. At the same time these experiments show conclusively that burning Rhenosterveld during the dry season is worse than useless as a means of improving the veld. The only result is to give a new lease of life to the Rhenoster bush—the one thing to be avoided. In this respect the Rhenoster bush is unlike *Helichrysum argyrophyllum*, another member of the Compositae, which in recent years has invaded large tracts of land in parts of the Eastern Province. In this case Dr. Schönland has shown that burning will eradicate the pest, which only gains the upper hand when over-grazing is practised (7). Clearing the veld, though rather an expensive operation, seems to be the most promising method of dealing with the Rhenoster problem, as under these conditions the Rhenoster bush shows no tendency to increase, and many plants suitable for grazing appear. It is interesting to note that Dr. Schönland, giving evidence before the Drought Investigation Com-

mission in 1923, states that in the neighbourhood of Grahamstown it has been shown that clearing the land of Rhenoster bush can be done with definite profit to the farmer. Returning to the problem as presented at Ida's Valley, it is possible that burning the veld a few weeks after the first winter rains have fallen may avoid many of the evils of summer burning. Evidence on this point, however, is too scanty for drawing definite conclusions at present.

More attention has been paid to the Rhenoster bush than to the other constituents of Rhenosterveld because the spread of this bush has proved such an unmitigated curse to the farming community. *Metalasia stricta* behaves in a similar manner, but the numbers are insufficiently large to render it of great importance. The *Pelargoniums* may be neglected, as although they too are stimulated by burning, they soon give way to their more shrubby competitors.

According to the results which have been obtained up to the present, clearing is favourable to the production of various grasses while burning tends to increase the number of petaloid monocotyledons. This monocotyledon stage in either case is a temporary one and its interest is largely theoretical, as under normal conditions grazing would certainly have modified the results.

The precise influence on the vegetation of the various animals previously mentioned is difficult to estimate. The Blesmol is almost certainly an important biotic factor, not only on account of its destructive habits, but because its extensive burrows and mounds must affect the water content of the upper layer of the soil and its physical constitution. The effect of grazing animals is more obvious, as a nutritious plant such as *Anthospermum aethiopicum* is severely handicapped in comparison with an inedible bush such as the Rhenoster.

The author is well aware that the small size of the experimental plots is a serious drawback in work of this nature. For this reason, apart from the many practical difficulties which existed, no attempt was made to include problems of grazing in the scope of the experiments. The small amount of unofficial grazing which took place is negligible and may therefore be discounted. Problems of burning and grazing should undoubtedly be studied in conjunction, but complete work of this kind can only be carried out on a large scale by full-time research officers in the agricultural schools. When these experiments were started there seemed to be no prospects of large-scale experiments being conducted, and the author decided to carry out intensive work on small plots in the hope that the results obtained might prove useful to future investigators. The present results are of sufficient interest to justify the investigation.

Summary.

1. The experiments described have extended over a period of two years.

2. Rhenosterveld is not a stable type of plant community, and evidence is brought forward to show that it must be a stage, although probably a protracted stage, in succession.

3. Burning leads to rapid increase of the Rhenoster bush and certain other plants. Burning also induces vigorous growth among the petaloid monocotyledons and some other plants. This vigour is of a temporary nature.

4. Clearing does not favour the rapid increase of the Rhenoster bush. In this case vigorous growth is more apparent among the grasses than among the petaloid monocotyledons.

5. The effect of various conditions on the germination and growth of the more important constituents of the vegetation is described.

6. Determinations of soil moisture, specific acidity, and soil temperature are given.

In conclusion I wish to thank Professor Adamson for his advice and many helpful discussions throughout the course of this work. To my husband, who has assisted me in the field at various times, and whose criticisms have been most valuable, I tender my grateful thanks.

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LIST OF ABBREVIATIONS AND SYMBOLS USED IN CONNECTION WITH THE QUADRATS.

(s) after any symbol denotes a seedling.

O placed round any symbol denotes plants (exclusive of geophytes) which were growing on the quadrat before the start of the experiments.

X placed on top of any symbol denotes that the plant was dead when listed.

A	*Anthospermum aethiopicum.*
Ac	*Aira caryophyllea.*
Ar	*Aristea* sp.
Asp.	*Aspalathus divaricata.*
Asp	*Aspalathus incurva.*
Bc	*Borbonia cordata.*
Bo	*Bobartia spathacea.*
Cb	*Cyphia bulbosa.*
Cr	*Crassula sphaeritis.*
D	*Dodonaea thunbergiana.*
Dp	*Drosera pauciflora.*
E	*Erica imbricata.*
Eh	*Ehrharta capensis.*
G	Undetermined grass or grass-like plant.
Gn	*Gnaphalium candidum.*
Hel	*Helichrysum teretifolium.*
Her	*Hermannia* sp.
Hl	*Hexaglottis longifolia.*
Las	*Lasiochloa ciliaris.*
Lb	*Lebeckia* sp.
Lc	*Lapeyrousia corymbosa.*
Leuc	*Leucadendron lanigerum.*
Lo	*Lachenalia orchioides.*
M	*Montinia acris.*
Me	*Mesembryanthemum gracile.*
Met	*Metalasia stricta.*
Mf	*Micranthus fistulosus.*
Ml	Leaf of petaloid Monocotyledon, too young to be determined.
Mo	*Mohria caffrorum.*
Mp	*Micranthus plantagineus.*
Mv	*Malvastrum albens.*
O	*Ornithogalum hirsutum.*
Op	*Oxalis purpurea.*
Os	*Oxalis sericea.*
Ov^1	*Oxalis versicolor.*
Ov^2	*Oxalis variabilis.*
P	Undetermined *Pelargonium.*
Pg	*Pelargonium grossularioides.*
Pm	*Pelargonium myrrhifolium.*
Pso	*Psoralea decumbens.*
Pt	*Pelargonium tabulare.*
R	*Restio cuspidatus.*
Rh	*Elytropappus Rhinocerotis.*
Roy	*Royena glabra.*
Ru	*Rumex acetosella.*
S	*Senecio pubigerus.*
Sel	*Selago* sp.
So	*Sonchus oleraceus.*
T	*Thesium strictum.*
V	*Vulpia bromoides.*
W	*Wahlenbergia cernua.*
X	Unknown seedling.
Y	Unknown small plant, not a seedling.

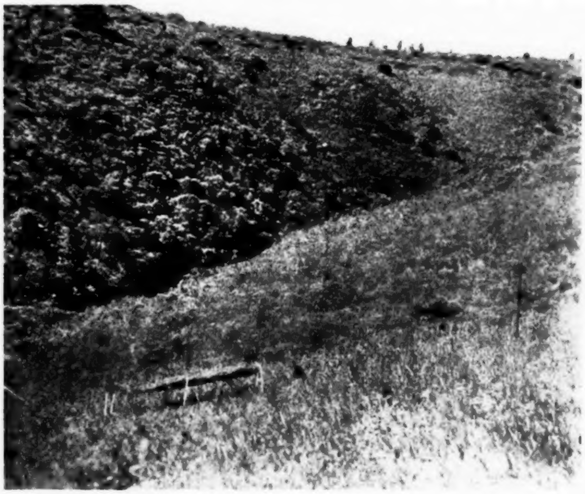

FIG. 1.—View taken from Plot 4, showing one of the light screens on the plot. Typical Rhenosterveld is seen outside the fence, while the opposite side of the valley is covered with proteaceous scrub.

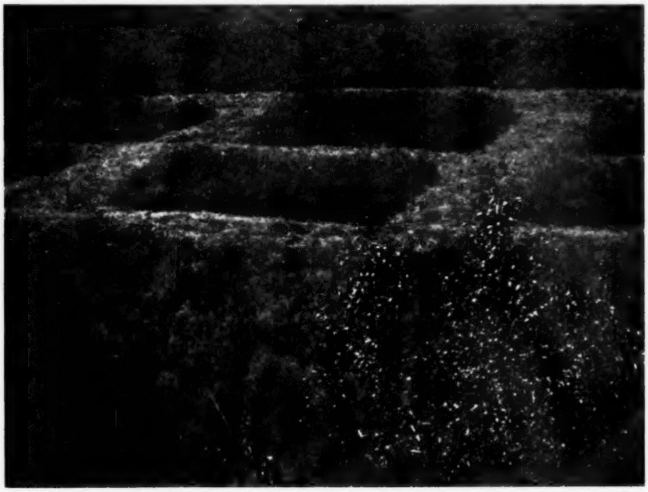

FIG. 2.—General view of portion of the experimental area showing the plots with fire-paths separating them. Photograph taken from the opposite side of the valley.

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Fig. 3.—Rhenosterveld on Plot 4 before clearing. The taller bushes in the foreground are *Dodonaea thunbergiana* and *Metalasia stricta*. The smaller bushes are chiefly the Rhenoster bush and *Anthospermum aethiopicum*.

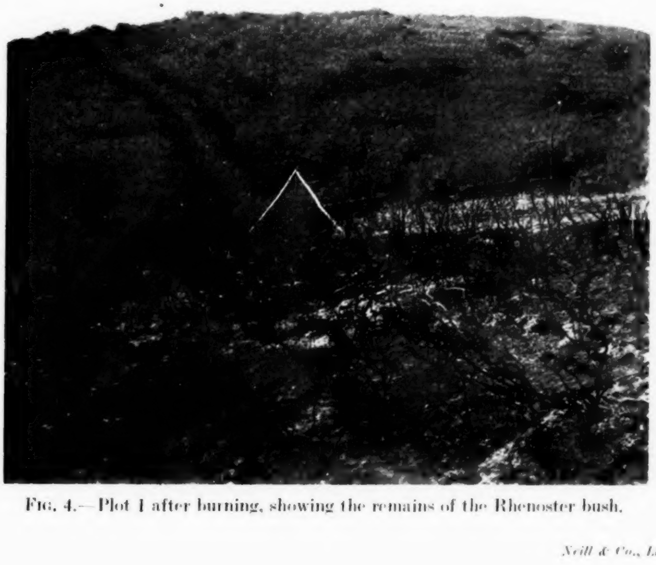

Fig. 4.—Plot 1 after burning, showing the remains of the Rhenoster bush.

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Fig. 5.—Plot 3. Before burning the foreground was covered with plants of *Erica imbricata*. No trace of these has been left by the fire.

Fig. 6.—Various seedlings on Plot 8. *Pelargonium tabulare*, *Pelargonium myrrhifolium* and *Anthospermum aethiopicum* are the principal ones.

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FIG. 7.—Plot 1. Detailed view of the vegetation in October 1926—a year and a half after burning. *Pelargonium myrrhifolium* and *Polygala bracteolata* are in flower.

FIG. 8.—Plot 4. Taken at the same time as fig. 7. Note the large number of grasses and the closed type of plant community.

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THE SPERMATOGENESIS OF *HOLOPTERNA ALATA* (WESTWOOD).

By Letitia Starke.

(From the Department of Zoology, University of Capetown.)
(Communicated by Professor Lancelot Hogben.)

(With four Text-figures.)

Introduction.

The study of cell division is of fundamental importance to the modern analysis of the material basis of inheritance, but the task of obtaining suitable materials for demonstrating the salient phenomena of animal cytology is one of considerable difficulty for the teacher in this country owing to the unsuitability of introduced species and the paucity of available information with reference to the South African fauna. Malan and Malan have recently (1926) given an excellent account of the spermatogenesis of the Brown Trek Locust, *Locustana pardalina*, but there do not seem to be any accessible data concerning a common Cape Peninsula species. Of all groups in the animal kingdom none have yielded more favourable material for laboratory work than the Hemiptera and Orthoptera. For that reason a study of the Spermatogenesis of the common Stink-bug, *Holopterna alata* was undertaken at the suggestion of Professor Lancelot Hogben.

The account which follows is based chiefly upon gonads of late male nymphs which may be obtained from September to February. The male gonad is easily identified from other organs which lie in the abdomen by its red colour. Immediately after decapitation the abdomen is opened and the gonad transferred to fixative within half a minute. Three fixatives were employed :

1. Flemming's formula without acetic.
2. Meves' modification of F.W.A. given in Gatenby's edition of "The Microtomist's Vade-Mecum."
3. Bouin's fluid modified with the addition of urea for work on insects, as advocated by Miss Carothers.

The latter gave excellent fixation of the chromosomes, but Meves' fluid yielded results which were equally satisfactory for the demonstration of nuclear phenomena, while at the same time preserving the cytoplasmic inclusions in a manner far superior to F.W.A. Unless elsewhere stated,

the figures given are based upon preparations fixed with Meves' fluid. All staining was carried out with Heidenhain's iron-haematoxylin.

The literature on insect spermatogenesis is now so extensive that there is no need to discuss the data in detail. The salient features will be set forth as briefly as possible, essential points being indicated in the accompanying figures, based on drawings made with ocular 10 Leitz and 2 mm. apochrome objective.

The testes of Holopterna are of the usual follicular type. Cysts of spermatogonia are found in adults or late nymphs only at the cephalad extremity of the testis, but spermatogonial mitoses are rare except in early larval mitoses. For seriation, continuity of appearance has to be relied on and the fact that cells within the same cyst are always in approximately the same stage.

1. Spermatogonia.

In the resting spermatogonia the mitochondria are seen as a dense tangle of very numerous attenuated filaments concentrated on one side of the nucleus (fig. 3 (1)). The spermatogonial counts of dividing nuclei showed 20 chromosomes (fig. 1 (1–3)). There is definite heteromorphism among these with respect to size, but insufficient to correlate with any differences in the spermatocyte mitoses. Careful study failed to detect differences which would serve to identify unequally paired (XY) elements.

2. Heterotype Prophase.

The material described did not provide sufficient favourable appearances to justify a discussion of the controversial issues which centre around the nature of the synaptic union. A typical pachytene bouquet is seen in fig. 1 (4). One point, however, is worthy of mention. In the female of nearly if not all animals which have so far been described from this standpoint there is intercalated between the diplotene stage and the appearance of the definite heterotype chromosomes a so-called diffuse stage which is usually co-extensive with the period of growth and yolk formation. An analogous stage in which the diplotène filaments assume a flocculent appearance is found in the spermatogenesis of many Hemiptera, as has been shown by Wilson and others. Such a stage occurs in the spermatogenesis of Holopterna. Fig. 1 (5) shows a nucleus emerging from this stage.

During the heterotype prophase the mitochondria present very much the same appearance as in the resting spermatogonia.

3. First Spermatocyte Division.

The number of chromosomes in the first spermatocyte mitosis is ten. The examination of a very large number did not lead to the detection of an

unequally mated pair, either in equatorial plates or in lateral views of the spindle (fig. 2 (9), (9*a*), (9*b*)). Exceptionally good figures of mitochondria in the first reduction division were obtained. Fig. 2 (6) shows a lateral view, (7) and (8) are polar views of the same cell at different depths.

4. Second Spermatocyte Division.

The second spermatocyte division is easily differentiated from the first by the smaller size of the definitive chromosomes and the more elongated spindle as indicated in fig. 2 (10), which also shows the distribution of the mitochondria. From this fact and the apparently smaller number of mitochondria it would appear that the second follows rapidly on the first reduction division without the intercalation of a growth-period. The number of chromosomes was in all cases found to be ten, and lateral views of spindles did not reveal a detectable differentiation of an XY pair.

5. Spermateliosis.

Exceedingly clear figures of the mitochondrial changes which accompany the transformation of the spermatids into the fully developed sperm were obtained. These changes are essentially like those which have been described by Bouin in other groups of insects. The tangle of mitochondria (fig. 3 (2)) first concentrates into a compact, deeply-staining mass of more or less spherical configuration (fig. 3 (3)). This then appears to display differentiation into chromophil and chromophobe portions (fig. 4 (5) and (6)). The mitochondrial mass is now seen to be separated into two symmetrical pear-shaped halves as indicated in fig. 3 (4) and fig. 4 (7) and (8). The elongation of the two-lobed mitosome (fig. 4 (9)) is apparently accompanied by a diminution in size of the nucleus and the first appearance of the flagellum. The subsequent transformation of the mitosome into the middle sheath of the sperm is indicated in fig. 4 (10), (10*a*), (11) and (12). In these stages a juxta-nuclear body which apparently corresponds to the archoplasm is identifiable, but the origin and fate of this body were not conclusively demonstrated.

Acknowledgment is made to Professor Newbery and Mr Herrman for kindness in supplying insects for this investigation, and also to the Government Research Grant Board for defraying expenses incurred.

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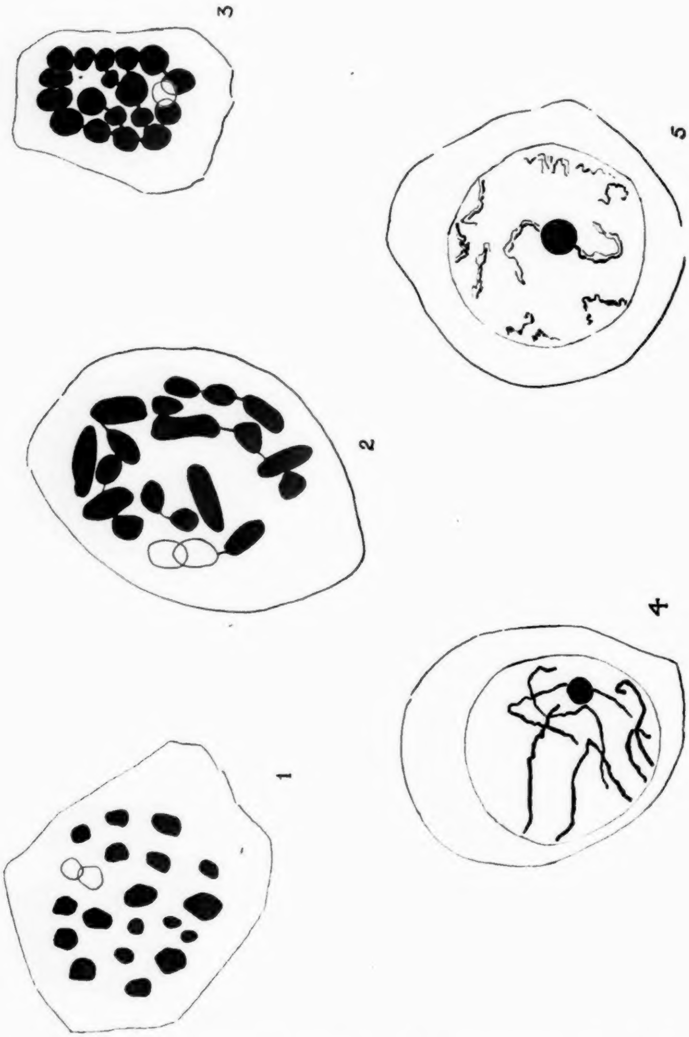

FIG. 1.—1, 2*, 3, Spermatogonial counts. 4*, Pachytene bouquet. 5*, Nucleus emerging from diplotene stage.

* Preparations fixed in Bouin's fluid.

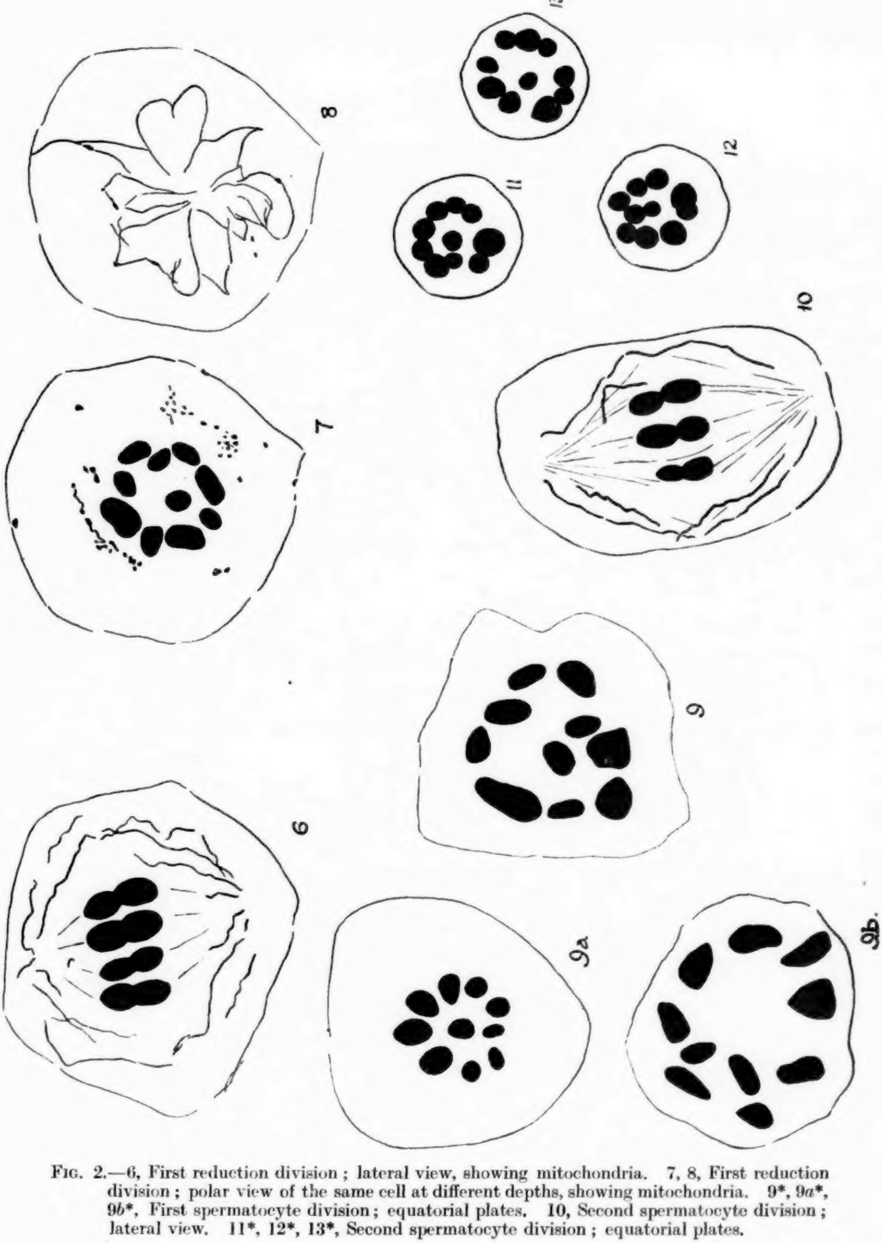

FIG. 2.—6, First reduction division; lateral view, showing mitochondria. 7, 8, First reduction division; polar view of the same cell at different depths, showing mitochondria. 9*, 9*a**, 9*b**, First spermatocyte division; equatorial plates. 10, Second spermatocyte division; lateral view. 11*, 12*, 13*, Second spermatocyte division; equatorial plates.

* Preparations fixed in Bouin's fluid.

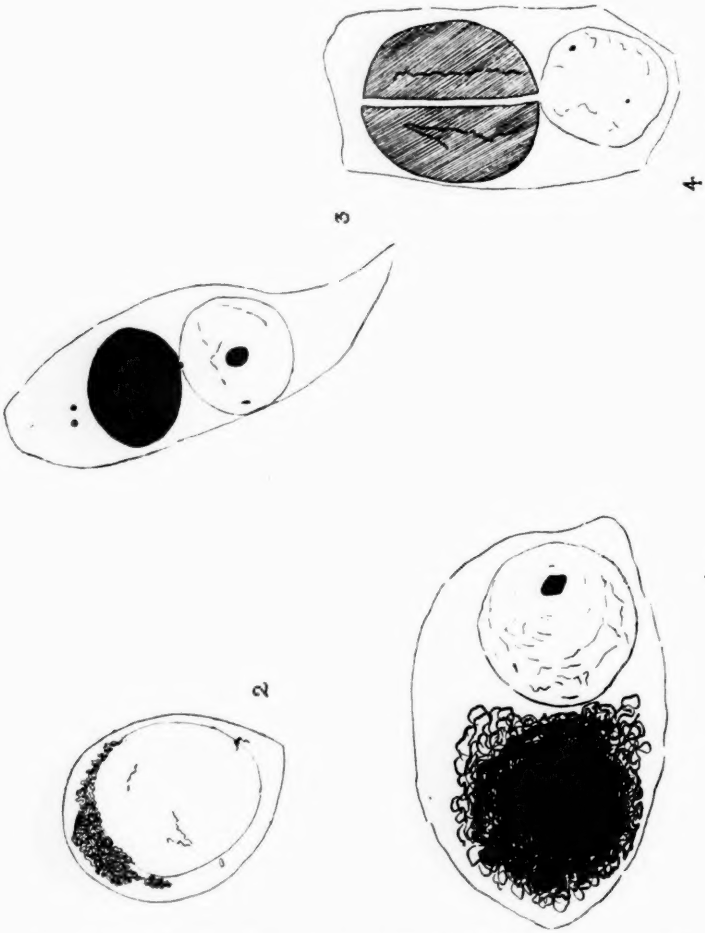

FIG. 3.—1, Resting spermatogonium with mitochondrial tangle. 2, Spermatid showing nucleus with mitochondrial cap. 3, Spermatid with mitochondrial mass. 4, Mitochondrial mass dividing.

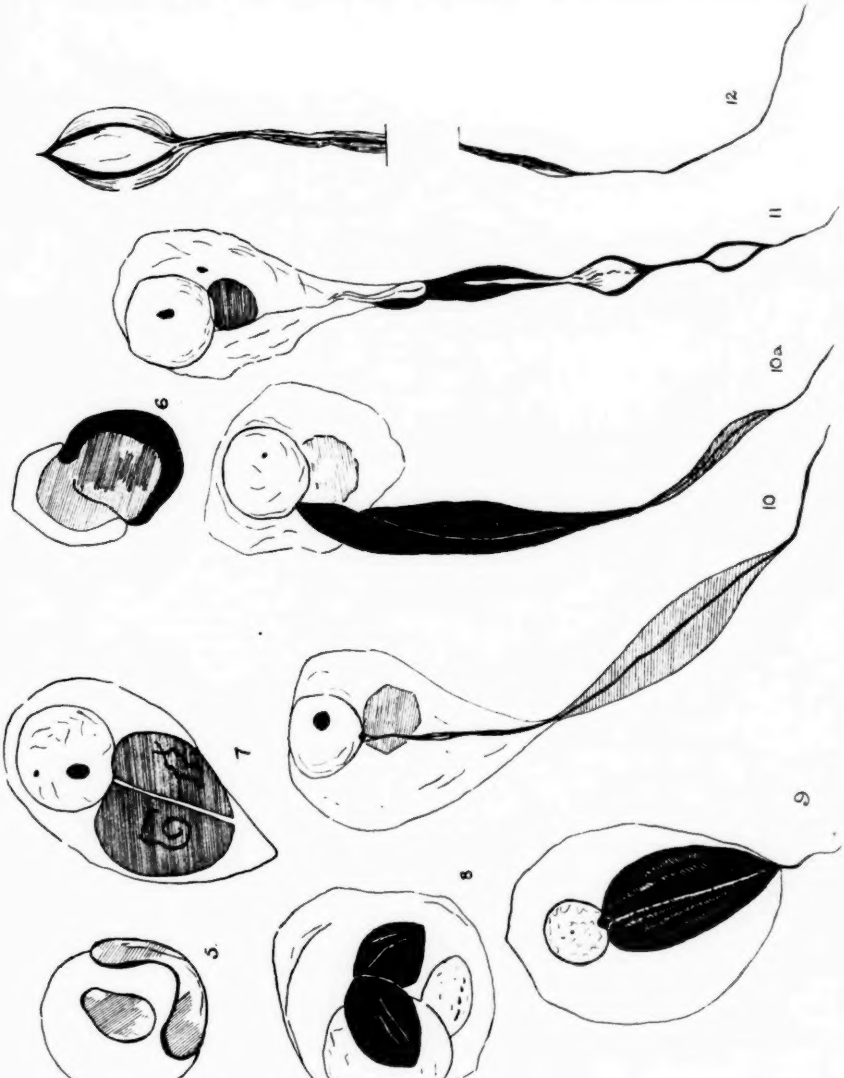

FIG. 4.—5, 6, Mitochondrial mass showing differentiation into chromophil and chromophobe portions. 7, 8, Division of mitochondrial mass. 9, Elongation of mitosome and appearance of flagellum. 10, 10*a*, 11, Transformation of mitosome into middle sheath of sperm. 12, Immature sperm.

THE INFLUENCE OF *USNEA* SP. (NEAR *BARBATA* FR.) UPON THE SUPPORTING TREE.

By John F. V. Phillips, D.Sc. (Edin.)

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The relationship of the widely distributed fruticose Discolichens of the genus *Usnea* to the trees supporting them has interested foresters in Europe, America, South Africa, and other parts of the world for many years, but so far as the writer has been able to ascertain, no thorough investigation of the subject has been attempted. It is interesting to note, however, that Coulter, Barnes and Cowles (1911, p. 803) state that some forms of lichens in temperate regions—*Usnea* for example—may be partially parasitic upon trees, while (*op. cit.* p. 659) they continue that even in cold climates the " beard lichens "—such as *Usnea* and *Alectoria*—may enfold the twigs of conifers to such a degree as to kill them : the hyphae of *Usnea* in some instances penetrating the living cells.

In the Knysna forests a species of *Usnea* (near *barbata* Fr.) drapes the crowns of large immature, mature, and over-mature *Podocarpus Thunbergii* Hook. (*latifolius* R. Br.), *Podo. elongata* Carr., *in part* (*falcatus* R. Br.), *Apodytes dimidiata* E. Mey., *Plectronia obovata* Sim, *Ocotea bullata* E. Mey., and various other species, but is particularly luxuriant and abundant upon the two species of *Podocarpus*. South African forest officers for long have speculated as to the exact significance of the seeming preference of *Usnea* for Podocarpus—more especially for *Podo. Thunbergii* Hook. (*latifolius* R. Br.) ; for this reason the writer investigated the relationship of the lichen and the supporting tree.

The object of the present communication is to describe *in outline* the results of this investigation.

Before describing the work done at Deepwalls, it will be instructive to consider briefly the work of Lars-Gunnar Romell (1922)—the only worker known to the writer to have investigated the relationship of lichens and the trees supporting them.

Romell, working in Norway, deals with the lichens *Alectoria sarmentosa* Ach. (" Grey Beard "), and *A. Fremontii* Tuckerm. (" Black Beard "), and

their relations with supporting *Picea excelsa.* He arrives at the following main conclusions :—

1. Light-intensity and humidity conditions within trees and stands cannot be correlated with occurrence of lichen.

2. Lichen cover is more luxuriant on living than on dead trees, perhaps because of the greater humidity in the former.

3. The lichen tresses are not fixed by haustoria or haptera except to a very limited degree, but are in position because of their being intertwined with the Spruce needles and branchlets ; true parasitism is therefore out of the question.

4. By careful infection experiments and the keeping *clean* of selected twigs, it is possible to demonstrate a definite correlation between the degree of lichen cover and the poor development of the buds and shoots.

5. By means of transects run through stands of Spruce on dry, transition, and swampy soils it is seen that there is a strong correlation between swampiness and density of lichen cover.

6. Transpiration is not reduced by dry tresses of lichen, but is strongly reduced when these are wet.

Romell sums up the position thus : the foregoing facts allow of no definite answer to the question of the capacity for destruction of the lichen cover, but certainly tend to show that the effect is not *primary* but *secondary*—a symptom of defective shoot-vigour.

The Spruces are lichen-clad because they are poor, not poor because they are lichen-clad. A rational system of sylviculture would remove the very trees that are lichen-clad : Sernander (1922, p. 243) probably is correct in his seeming paradox that *Alectoria Fremontii* is " the true destroying angel of Spruce."

The Influence of *Usnea* (near *barbata* Fr.) upon *Podocarpus* spp.

The exact objects of the investigation were to elucidate the following problems :—

1. How does *Usnea* (nr. *barbata* Fr.) obtain position upon the supporting tree ?

2. What is the exact role of the lichen ? Is the lichen present because the tree is deficient in vigour, or is the tree deficient in vigour because of the action of the lichen ?

3. Why are the two species of *Podocarpus* especially favoured by *Usnea ?*

In the investigation of these problems anatomical study, infection experiments, transpiration experiments, and instrumental measurement of the prime aerial and edaphic factors under consideration, were carried out.

The results of the work may be recorded most succinctly under paragraph numbers, the numbers corresponding with those given in the summary of Romell's work, above.

1. Unlike the *Alectoria* spp., increase in *Usnea* covering is directly correlated with increased air-temperature and light-intensity, with corresponding increase in rate of evaporation and decrease in humidity. Crowns of both species of *Podocarpus* protected from the severe insolation existing during the hours 11 a.m.–3 p.m., on exploited sites of large dimensions, and above the crowns of the dominant trees of undisturbed forest, may show either no sign of *Usnea*, or at most, a slight infection only, *whereas* crowns fully exposed—whether from exploitation or because of their belonging to dominants that have held sway in the uppermost layer for ages—are usually very densely covered with *Usnea*. Individuals that under fairly closed conditions of canopy (light-intensity at 40 to 50 feet, 0·04–0·02, on bright days between 11 a.m. and 3 p.m.—full exposure to sunshine being 1·0) show little or no *Usnea*, within five years of exposure to severe insolation exhibit very appreciable amounts of the lichen ; their originally entirely fresh leaders and upper laterals, at the end of three to five years, have lost much of their foliage, and appear desiccated and non-vigorous. Trees of the same species, and of much the same original vigour, growing in close proximity, but kept fairly free of *Usnea* by means of mechanical removal of the thalli, exhibit much healthier, better foilaged leaders and upper laterals.

Experimental infection of *Podocarpus*—of sapling, pole, and mature stages—growing under the cool and humid conditions prevailing within undisturbed high forest, while successful, in that it was possible to establish the lichen by means of either the *soredia* or short portions of thallus twined round the leaves and fine twigs, has shown quite clearly that rapid development of the organism under dense forest conditions is entirely impossible. In Nature luxuriant growth of lichen may be observed from time to time upon trees experiencing high humidity and low light-intensity, but careful examination of these seeming " growths " reveals the fact that they are merely very large tresses that have fallen from the trees of the upper storey, and have bound themselves around individuals in the lower layers. If such " growths " be observed for any length of time, it will be seen that they either desiccate and ultimately die, or at most make a feeble attempt to establishment, but slowly decrease in vigour until they are shrunken to very small dimensions compared with their original ones.

Experimental infection of trees of various stages, under severe conditions of temperature, humidity, and light between the critical hours of 11 a.m. and 3 p.m., however, results in rapid development of the thalli.

2. As in *Alectoria* spp., *Usnea* is more luxuriant on still living than on

dead trees ; the possible explanation of this is given under the next paragraph. Unlike the case in *Alectoria* and Spruce, *Usnea* is frequently strongly developed upon the most vigorous trees : upon splendid, large, semi-mature and mature trees with boles showing excellent girth-increment per annum, and with large healthy crowns—the latter exposed to insolation. Vigorous, younger stage trees upon insolated sites, too, show strong lichen growth.

3. Unlike *Alectoria*, *Usnea* (nr. *barbata* Fr.) is definitely parasitic in very many instances. Microscopic examination of a wide range of material taken from trees of various stages, growing under diverse conditions of habitat, and taken at different times of the year over a period of about five years, shows the following features :—

(*a*) Mycelium of the fungal component is found within the cork-cambium and within the tissues external to this.

(*b*) At times the mycelium is found on the inner side of the cork-cambium.

(*c*) The strands are developed strongly as a rule, the tissues in their vicinity being in a state of decomposition, incipient or advanced.

(*d*) Favoured points of attachment appear to be the leaf-scars, the fungal element penetrating at these points of weakness, and then ramifying superficially within the tissues.

(*e*) In severely covered trees, branchlets in varying stages of degeneration are found : from those that as yet bear no evidence of discomfort external or internal, through those that show obvious signs of discomfort, to those that are either dying or dead. Pieces of thallus placed upon suitably exposed portions of branchlets still attached to the parent tree, fix themselves by means of the typical attachment discs, and within a year commence to produce slight decomposition of the outer tissues. With increasing age of the attached thallus, the mycelium ramifies further and further in a horizontal plane, and in various places penetrates into the cork-cambium and layers internal to this : the damage thus wrought in the tissues is cumulative.

4. As in the case of *Alectoria* and Spruce, there is a definite correlation between the degree of *Usnea* cover and the poor development of buds and shoots of *Podocarpus* spp. Many buds fail to develop, others produce abnormal shoots of small dimensions ; development of the foliage is thus much inhibited, with the result that the crowns by degrees begin to thin, and to appear " stag-headed."

5. Transect data go to show that *Podocarpus* spp. within the *Dry type* (holard, 25–35 per cent. at 12–18 inches on dry-weight) Knysna forest are usually more densely *Usnea*-clad than they are in the *Medium-moist type* (holard, 45–60 per cent.) and in the *Moist type* (holard, 100–170 per cent.)

of the plateaux and the mountains. This possibly is to be explained by the fact that the conditions for growth are much less congenial in the *Dry type* than in the other *types*, the trees being undersized, the crowns poorly developed, and the boles of very low rate of girth-increment.

It has been noted, further, that within the *Medium-moist type*, *Usnea* is more abundant upon trees growing in shallow soils than upon those growing in deep, while trees in exposed, windswept sites are more densely clad than those in protected.

In essence these findings agree with those of Romell concerning lichen-clad trees being more abundant in swampy ground than in well-drained: the uncongenial conditions probably assisting the lichen to develop in virtue of their unfavourable reaction upon the supporting trees.

6. Transpiration in densely clad *Podocarpus* is decreased as the result of *Usnea* attack if the tresses of the lichen closely cover the transpiring organs; this cannot, however, be considered as a factor detrimental to the tree; probably in certain periods—for example when the hot, dry Foehn-like "Berg" winds are blowing—the presence of *Usnea* actually may be beneficial.

No chemical methods of determining the influence of *Usnea* upon the assimilative capacity of the foliage of infested trees were attempted, owing to the unsuitable nature of the standard methods.

Quantitative comparison of the increment in very young foliage under cover of dense tresses of the lichen and in equivalent-aged foliage free of lichen cover, leads to the conclusion that there is a definite reduction in assimilative capacity in the former. Actual measurement shows that the tresses cut down the light-intensity from a normal of 1·0 to 0·1 or 0·04, a decrease probably sufficient to make an appreciable difference to the amount of food elaborated by the leaves. At the same time it must be remembered that the mycelial portion of the lichen is filching moisture and solutes from the developing leaves, this probably having much more influence upon the growth of the latter than has the cutting-down of the light-intensity.

Summing up, the writer would answer the three questions he set out to investigate thus:

1. *Usnea* (nr. *barbata* Fr.) obtains position upon trees by means of *soredia* produced in extreme abundance, and by means of windblown portions of thallus that attach themselves to leaf-scars or abrasions by means of discs. During high winds (forces 5 to 8 on the Beaufort Scale) portions of thallus are tossed as much as several hundred yards.

2. The fungal portion of the lichen is parasitic: the crowns of many trees in congenial situations are poor because of this gradual parasitism, and *Usnea* is not luxuriantly developed upon them simply because they are

trees poor in condition. It must be conceded, however, that there is every indication that crowns damaged by wind, hail, or other cause, or crowns in a low state of vigour on account of uncongenial aerial, edaphic, or biotic factors, are more susceptible to development of dense *Usnea*, and to the effects of this.

Vigorous trees do not show the same detrimental effects as do poorly-grown ones, as the lichen takes a fairly long period in which to bring about marked effects.

3. A probable explanation of the fact that *Podocarpus* spp. are particularly attacked may reside in the bark of the conifers being a more congenial substratum than that of the dicotyledonous trees.

The bark of the *Podocarpus Thunbergii* Hook., at all events, is more water-permeable than are the barks of the "Hardwoods" in the Knysna forests; to *Podo. Thunbergii* Hook., *Podo. elongata* Carr. is a good second. Experimental infection work has shown that the organism more readily establishes itself in the soft, porous, very slightly resinous, water-retaining outer tissues of the branchlets of these two conifers than it does in the outer tissues of *Apodytes*, *Ocotea*, and several other dicotyls, and more readily in the tissues of these species than in those of the rest of the Knysna species.

The leaf-scars in the *Podocarpus* species are more readily probed by the mycelium of the fungal component than are those of the "Hardwood" species: probably a second reason why *Usnea* is more abundant on the two conifers than on the "Hardwoods."

Preventive and Remedial Measures in Sylviculture.

Remedial measures, except in the very earliest stages of infection of small planted stands, or of isolated individuals of particular interest and importance, are quite out of the question in general practical sylviculture. In the instances mentioned, removal of the first small thalli, from time to time, doubtless would act beneficially. Remedial measures in the primeval forests, however, could not be considered for a moment.

Preventive measures, however, are quite possible in the latter: one of the most potent means of preventing further development of the organism would be to retain a fairly intact canopy, avoiding the formation of large gaps or "focus spots" admitting severe insolation to sapling, pole, and small tree stages that hitherto have experienced dense shade and high humidity. The sudden opening of the canopy to the forces of insolation reacts in two ways: it firstly weakens the general vigour of the exposed individuals, more especially the leading shoots; secondly, the increased temperature, decreased humidity, increased evaporation tend to aid the development of the lichen.

In plantation formation, due selection of site according to species requirement—so that vigorous growth is possible—is the best safeguard against *Usnea* infection.

Summary.

1. The influence of *Usnea* sp. (near *barbata* Fr.) upon *Podocarpus Thunbergii* Hook. (*Podo. latifolius* R. Br.) and *Podo. elongata* Carr. (*falcatus* R. Br.) in the Knysna forests, has been a subject of much interest to forest officers for some decades.

2. Romell working with species of *Alectoria* commonly found upon *Picea excelsa* in Norway, concludes that the effect is *secondary* and not *primary*: *Alectoria* is a symptom of defective shoot-vigour. His valuable and interesting researches are outlined.

3. Research, employing anatomical study, infection experiments, transpiration experiments, instrumental measurement of the prime aerial and edaphic factors under consideration, and general observation, has been carried out at the Research Station, Deepwalls, Kynsna, into the relationship between *Usnea* and the *Podocarps*.

4. A general summary of results and of conclusions is given.

5. It is concluded that the lichen is definitely detrimental, in that its fungal component is parasitic upon the tissues external to (and sometimes internal to) the cork-cambium. Vigorous crowns may be infected as well as defective ones.

6. The lichen cannot develop luxuriantly under the conditions of light, temperature, and humidity holding in undisturbed high forest, but grows apace when these factors are suddenly and severely altered by heavy exploitation.

7. Preservation of the forest canopy in primeval forest would seem to be the very best means of inhibiting the rampant development of the lichen.

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NOTES ON THE HABITS AND LIFE-HISTORIES OF SOME CAPE PENINSULA ANURA.

By J. H. Power and W. Rose.

(With Plate V and two Text-figures.)

Bufo rosei, Hewitt.

Hewitt, Ann. S.A. Mus., vol. xx, p. 417, 1926.

This remarkable little toad, which is apparently confined to the Cape Peninsula, was first discovered on the plateau above Muizenberg in March 1925. Since then it has been found near Cape Point and on the side of Table Mountain, so in all probability it occurs all along the higher altitudes of the Peninsula.

It is interesting to note that the maximum size of some hundred specimens from Muizenberg plateau (1100 feet altitude) was 26 mm., the average being about 20 mm., those from the south end of the Peninsula (about 800 feet altitude) being somewhat smaller, while the maximum attained by a series from Table Mountain (3300 feet altitude) was 37 mm., the average being about 30 mm.

A small specimen (15·3 mm. from snout to vent) in the S. African Museum, collected in January 1927 by Dr. K. H. Barnard in the Cedarbergen below Tafelberg, at a band of shale 3500 feet up, agrees in every particular with *B. rosei*, even to the corrugated area over the fat bodies, save that the tympanum is present though very indistinct. This specimen seems to be a link between *B. rosei* and *B. tradouwi*.

The absence of a tympanum in the species seems to preclude the possibility of vocal effort on the part of the male during the breeding season. No call has yet been observed, and we suggest, with due reserve, that in all probability the sexes resort to small pools after rain and by moving about therein come into contact with each other; this of course infers that the species is in sufficient numbers to have some of both sexes at a given pool. The large corrugated oval patch over the fat bodies ventrally is a bright pink in the breeding season in both sexes. In the absence of a voice, this may be a means of sex attraction through the medium of

smell, though experiments conducted to test this theory gave negative results.

Some twenty-four pairs were found breeding on the slopes of Table Mountain on August the 18th at an altitude of 3000 to 3300 feet in a small pool of rain water, 4×2 feet and 4 inches deep in the centre. It is interesting to note that this identical spot was visited two weeks before, there being no puddle there on that occasion. Close at hand, however, on both visits was a small running stream with occasional pools, but these seemed of no interest to *B. rosei*. That it was ready and anxious to spawn is obvious from the fact that it took immediate advantage of the pool, which we know was formed over night on the 18th. There were no weeds or plants in the pool to which the eggs could be attached, consequently they rested on the bottom in a mass.

The eggs (Pl. V, fig. 1) are exceptionally large, being 3·0 mm. in diameter, they are enclosed in an inner spherical capsule 4·0 mm. in diameter, and an outer oval capsule having a major axis 5·5 mm. and a minor axis of from 4·7 to 5·0 mm. They are connected by cylindrical tubes of jelly 1·5 mm. in diameter at the centre when there is no tension. When suspended by the hand, the tension causes the connecting tubes to become very attenuated, the vitellus under such circumstances being exactly 25 mm. apart. When lying naturally at rest the distance from centre to centre is 8·0 mm.

The embrace is in the axillary region, the palms of the male's hands being directed forward.

The number of eggs laid by each female is estimated roughly at 7000; when first laid the chains of jelly-like capsules are transparent, and when held up look exactly like strings of black-centred glass beads, but suspended matter in the water soon adheres to them, rendering them quite opaque.

On the morning of August 23rd the embryos had hatched, they were jet black and rested in the vitelline membrane as in a semi-transparent sphere of milk-white glass which showed up against the transparent capsules. At this stage the outer capsule measured 8·0 mm. major axis, 6·0 mm. minor axis; the embryos measured 4·5 mm.

24/8/27.—The white vitellus had burst and clung in a collapsed state to the side of the embryo. The larvae at this stage measured 5·0 mm.; a small tail and body had formed. The major axis of the outer capsule measured 9·0 mm., the minor axis 7·0 mm.

26/8/27.—The embryos measured 6·0 mm. Owing to an unusual drop in temperature, metamorphosis was retarded at this stage.

30/8/27.—By this date they had left the egg-capsules; the largest then measured, total length, 10·5 mm., tail, 6·0 mm. The external gills had

just begun to appear; the head, body, and tail were very distinct from each other.

2/9/27.—The external gills were fast disappearing; at their largest they were very poorly developed, being scarcely visible under a strong lens. The legs began to appear on this date.

7/9/27.—At this stage the largest specimens measured 17·0 mm. total length, of this the tail occupied 12·0 mm. This is an unusually long tail; it measured only 2·0 mm. broad and was of a uniform width almost from end to end. The lips and mouth were formed at this time; the adhesive apparatus was fast disappearing; the external gills had been entirely absorbed.

10/9/27.—The eyes and nostrils were fully formed on this date, also the mouth parts.

28/9/27.—Total length, 19 mm.; tail, 13 mm. At this early stage the oval corrugated patch over the fat bodies, so characteristic of the adult, began to appear in the shape of circular dark grey pads at the origin of each leg and in front of the anus. The spiraculum was first observed at this stage almost on the ventral surface and at the left side.

1/10/27.—Total length, 21·5 mm.; tail, 15·0 mm. This was the greatest length reached.

3/10/27.—Total length, 21·5 mm.; tail, 15·0 mm. The arms came through about this time in no regular order, the right or left appearing first. In the case of some specimens taken from a small artificial pool on this date the tail was almost completely absorbed. Further, it was noted that tadpoles kept in aquaria where they could leave the water, completed the metamorphosis in much quicker time than those kept in vessels with perpendicular sides.

13/10/27.—Metamorphosis was completed by this date; the tiny toads measured 6·25 mm. from snout to vent. Thus the development took fifty-one days to complete in a steep-sided glass vessel, and in its final stages was somewhat accelerated by the removal of most of the water and tilting the vessel. The tadpoles in the small artificial pool referred to above took just six weeks. It would appear from this that under natural conditions development is much accelerated by the lukewarm conditions that must prevail in puddles such as that in which the eggs were found, and which in many cases can only be of a very temporary nature.

The Tadpole, text-fig. 1, length, 21·5 mm.

Body.—Length of body about $1\frac{2}{3}$ times its width; considerably less than half the length of the tail. Nostrils nearer the eyes than the end of the snout. Eyes on the upper surface, the distance between them about equal

to that between the nostrils; equal to the width of the mouth. The body is so dark that the nostrils are very indistinct.

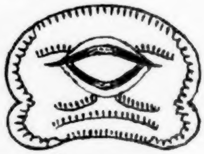
Spiraculum.—The spiracular opening is situated almost ventrally; on the left side; visible from below; not visible from above; nearer the snout than the anus; directed backwards; very indistinct.

TEXT-FIG. 1.

Anus.—The anal opening is median, on the lower edge of the sub-caudal fin.

Tail.—Tail almost six times as long as deep, obtusely rounded, and occasionally turned up slightly at the end; upper crest begins about one-third of the length from the origin of the legs, slightly deeper than the lower and slightly convex; the lower crest extends the full length of the tail, almost straight; the depth of the muscular part at its base two-thirds the greatest total depth.

Mouth Disc (text-fig. 2).—Beak, white edged with black; lips with papillae only at the sides which form an inward fold, both upper and lower toothed, the series being represented by the formula $\frac{\begin{matrix}1\\1\ \ 1\end{matrix}}{\begin{matrix}1\ \ 1\\1\\1\end{matrix}}$; the second upper series very short and broadly interrupted in the centre; the first lower series divided in the centre, the second and third lower series uninterrupted.



TEXT-FIG. 2.

Colour.—Jet black throughout, even the eyes are so covered with black pigment as to be almost hidden. The tail fins are of a dull mouse colour.

Habits.—Owing to the unusually long tail, the swimming action is more serpentiform than in any other tadpole known to the authors. The tadpoles do not move about in colónies, but seem to prefer to lie in the mud at the bottom of the pool; at, times, however, they display considerable activity.

Hyperolius horstockii (Schleg.).

Schleg., Abbildung., p. 24, 1884.

The breeding season of this species in the Cape Peninsula is early spring. The male has an external vocal sac which, when fully inflated, makes the creature appear twice its normal size. The call is a loud rasping *Chee, Chee, Chee*; the female is seized in the axillary region, the hands of the male

being pressed well into the armpits. The embrace is maintained even when the pair is handled.

The eggs, to the number of about twenty-five to thirty, are laid in small masses at the foot and right in the centre of clusters of rushes, tufts of grass, or other plants in the water. These egg-masses are so concealed that even when laid in an aquarium where there are only a few tufts of grass or weeds, they are most difficult to locate.

Eggs laid in an aquarium on the night of October the 9th measured 1·75 mm.; they were enclosed in mucilaginous transparent capsules which measured 4·75 mm.; by October 11th the larvae had hatched (see Pl. V, fig. 2).

On October 18th the larvae left the capsules; they then measured, total length, 6·0 mm., tail, 3·5 mm.; the swimming action was very rapid and spasmodic. They lay inert at the bottom of the aquarium most of the day; the external gills were visible at this stage.

Development seems to be rather slow, for a month later on November 18th the total length was only 10·0 mm., tail, 6·0 mm. At this stage the eyes, gut, mouth, etc., were formed and functioning, including the spiraculum, which was visible on the left side. The body was now covered with minute brick-red spots.

On December 3rd all the larvae were found dead and so soft and crumpled up that accurate measurement was impossible. The following account of the tadpole has been drawn up from specimens preserved on November 18th, which, though far from being fully developed, are in a fair state of preservation. They are, however, sufficiently advanced to show that they are typically ranid in character.

The Tadpole, Pl. V, fig. 4, *a* and *b* (immature), total length, 10·0 mm.

Body.—Length of body about $1\frac{2}{5}$ times its width; slightly less than half the length of the tail. Eyes situated dorsally, not visible from below, the distance between them $1\frac{4}{7}$ times that between the nostrils, about equal to the width of the mouth.

Spiraculum.—Spiracular opening prominent about the middle of the left side, directed backwards and upwards.

Anus.—Anal opening median, on the lower edge of the subcaudal fin.

Tail.—Tail $2\frac{4}{5}$ times as long as deep, acutely rounded at the end; upper and lower crests convex; upper crest not extending on to the back.

Mouth-disc (Pl. V, fig. 4, *c*).—Disc subcircular; lower lip bordered with rather long papillae in two rows; the upper lip toothed. There are only two series of teeth at this stage, the single lower series extending the full width of the mouth.

Colour.—Body and muscular tail covered with minute bright, brick-red spots.

Arthroleptella lightfooti (Boul.).

Boul., Ann. S. Afr. Mus., vol. v, pp. 529 and 538, 1910.

Though damp mountain gorges seem to be the typical habitat of this little frog, it may also be found in the grass beside some of the plateau streams and marshes in conjunction with *Rana fuscigula*, *R. grayi*, *R. fasciata*, and *Bufo rosei*.

Up to the present, *Arthroleptella lightfooti* has been recorded from the Cape Peninsula only, and probably those in this locality can be separated into two or more sub-species. Those found in the gorges average 19 mm., while the plateau type averages only 16 mm. from snout to vent.

The breeding season of this species is spring and early summer. The male has an external vocal sac which when fully inflated is about half the size of the body. The voice is a high-pitched chirp like that of a cricket.

The eggs are practically all yolk and are laid in clusters of five under damp moss that is kept moist by seepage or splashing. They are very large, quite exceptionally so for the size of the frog, the nucleus being 4·0 mm.; with the transparent jelly-like capsule they measure 8·0 mm.

Development is very rapid in warm weather, taking only ten days from egg to froglet.

The tadpoles reach an advanced stage before leaving the capsule; they measure, total length, 13·0 mm.; tail, 9·0 mm.; the legs are 1·5 mm. long, and the toes are visible. The jelly-like capsules reach 12·0 mm. in diameter before the larvae rupture them and escape. They then wriggle about in the moss and seem to be quite unable to swim, notwithstanding the highly developed tail; they twitch spasmodically when placed in water.

No trace of external gills is noticeable at any stage of the development.

The Tadpole (Pl. V, fig. 3), total length, 13·0 mm.

Body.—Length of body $1\frac{2}{3}$ times its width, nearly $\frac{2}{3}$ the length of the tail. Nostrils nearer the end of the snout than the eyes. The eyes are very prominent and situated laterally, visible from above and below, the distance between them about twice that between the nostrils.

Spiraculum.—No trace of the spiracular opening could be found in the stages before the tadpoles left the egg-capsules. In the later stages, when the legs are fully developed and the hands are showing beneath the skin, a triangular-shaped opening is visible just over the left hand (see Pl. V, fig. 3).

Anus.—The anal opening is median, situated at the origin of the legs.

Tail.—Tail $4\frac{1}{2}$ times as long as deep, acutely rounded at the end; the upper crest begins above the origin of the legs, slightly deeper than the

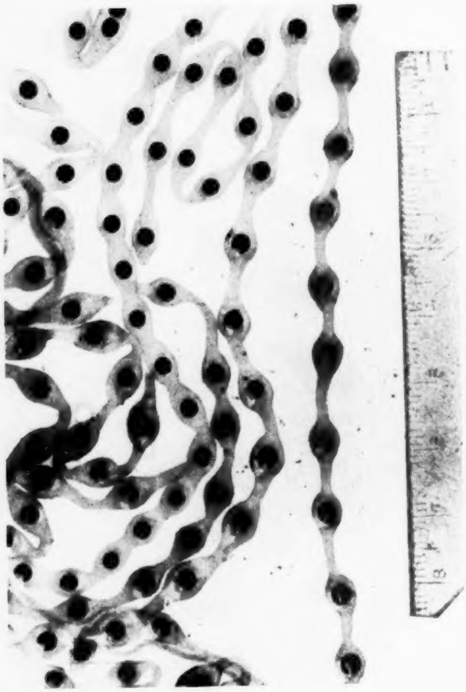


Fig. 1.

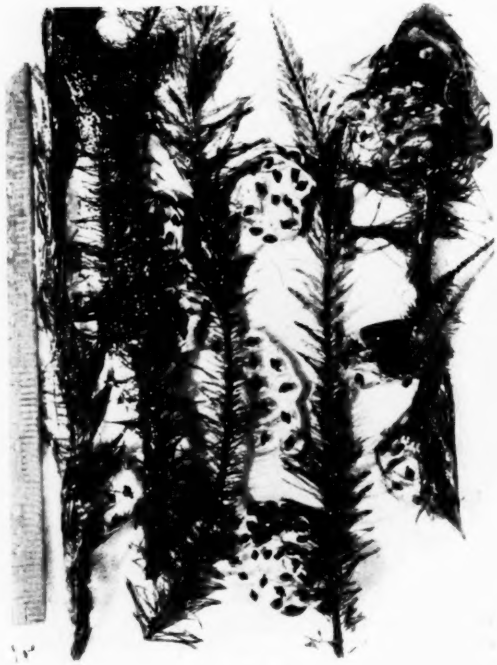


Fig. 2.

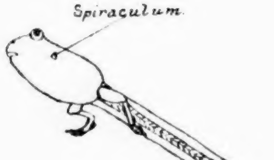


Fig. 3.

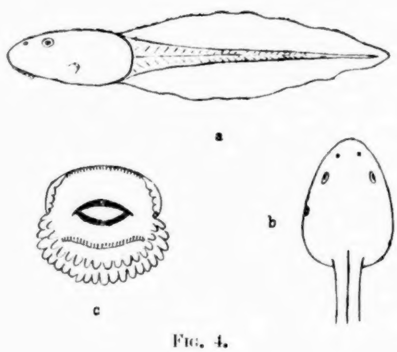


Fig. 4.

Neill & Co., Ltd.

lower ; upper and lower crests almost straight ; the depth of the muscular part at its base is about half the greatest total depth.

Mouth Disc.—The usual mouth disc is completely absent, there being no horny beak, labial teeth, or papillae. The mouth is a small transverse opening with smooth white lips. Even at the most advanced stage, just before the arms come through, there is no indication of a spiral gut ; apparently the tadpoles subsist entirely on the yolk during metamorphosis.

Colour.—Body, dark brown above, yellowish below ; tail, yellowish with transparent fins.

Habits.—When the tadpole leaves the capsule it wriggles about among the damp moss until metamorphosis is completed.

EXPLANATION OF PLATE.

Plate V.

1. The eggs of *Bufo rosei*, natural size.
2. Showing several groups of newly hatched larvae of *Hyperolius horstocki*, natural size.
3. The tadpole of *Arthroleptella lightfooti*, much enlarged.
4. *a* and *b*, the tadpole of *Hyperolius horstocki* ; *c*, the mouth disc of same, much enlarged.

MEAN SEA-LEVEL AND OTHER TIDAL PHENOMENA IN TABLE BAY, SOUTH AFRICA.

By Jan Dommisse, Ph.D., Lecturer, Grey University College, Bloemfontein.

(With one Text-figure).

Introduction.

The paper of which this is but a brief summary may be seen at the Library of the University of Cape Town. The work is divided into five portions: (*a*) Mean Sea-level at Cape Town, (*b*) Correlation between M.S.L. and Barometric Pressure, (*c*) Nineteen-yearly Tide, (*d*) Phenomenon of 1907, and (*e*) Tide Constants.

Mean Sea Level (M.S.L.).

The heights of the high tides and low tides, as recorded by the Legé Tide-Gauge in the Clock Tower, Table Bay Harbour, were obtained with reference to the L.W.O.S.T. These were taken over a period of fifteen years and averaged, with the result that the M.S.L. is 2·43 British feet above the L.W.O.S.T. The M.S.L. for each year was found and plotted against the time, but no general trend was found indicating relative movement between the M.S.L. and the land.

Correlation of M.S.L. and Barometric Pressure during 1904.

At the suggestion of Professor Morrison, University of Stellenbosch, it was decided to find the degree of correlation existing between the M.S.L. and barometric pressures. The barometric pressures were obtained from the Royal Observatory, and were then correlated with the M.S.L. readings by the usual method. The correlation factor was found to be $= -0{\cdot}491$. The smallness of the factor indicates the presence of irregular disturbing influences, of which wind action is likely to be important.

Nineteen-yearly Tide.

In reading through G. H. Darwin's "Scientific Papers" it was noticed that he experienced great difficulty and, as a matter of fact, failed in attempting to detect the nineteen-yearly tide at Bombay. The method followed was to find the average heights of the M.S.L. for every five months, plot them on a graph, and then in addition to plot the cosine curve given in his work as representing the nineteen-yearly tide in harmonic notation. The graph shows that the actual change in M.S.L. between 1903 and 1910 was nearly 1·20 feet, and this is just twenty-three times the maximum range of the nineteen-yearly tide, namely, 0·052 feet. It is thus obvious that this tide must be entirely masked by changes of sea-level arising from meteorological causes. This conclusion goes to strengthen Sir G. H. Darwin's statement that "it seems unlikely that what is true of Karachi and Bombay is untrue at other ports, and therefore we must regard it as extremely improbable that the nineteen-yearly tide will ever be detected."

Phenomenon in 1907.

In going through the tide-gauge records, a very striking phenomenon was observed which took place in February 1907. In brief, instead of a high tide of 3·4 feet (say) at 10 p.m., we find two high tides of height 2·5 feet each at 7.30 p.m. and 12 midnight, and a low tide of 1·8 feet at 10 p.m. A rough sketch is given below.

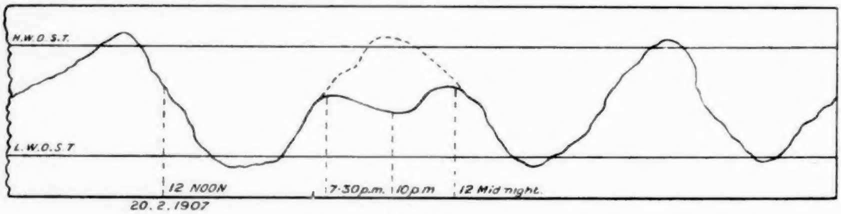


Fig. 1.

The phenomenon has been thoroughly examined and has been proved not to be due to (1) seismic disturbances, (2) barometric fluctuations, (3) ordinary forced harmonics, (4) machine defects, (5) well defects. The only unusual happening at the time was a very strong N.W. wind with a magnitude of 6 on the Beaufort Scale on the 20th of February. The N.W. wind would cause the water to be piled up on the shores of the bay containing the tide-gauge. Is it not possible that, taking the configuration of Table Bay Harbour into account, we find a sort of harmonic exercising this effect on the tides and causing an effect somewhat similar to that of a

forced harmonic ? In view of the fact that all other hypotheses fail, this seems to be the only possible explanation of this strange phenomenon.

TIDE CONSTANTS.

Hourly observations, stretching over two periods of approximately seventy-four days each, from 13th February to 30th April 1911, and from 14th August to 31st October 1914, were obtained. These were analysed according to the method suggested by G. H. Darwin in his "Scientific Papers." The necessary arguments and factors for the two periods were computed, giving the following tide constants :—

Tide Constants.		February 1911.	August 1914.	Finlay's Work.	My old Results.
	A*o*	2·1 feet	2·4 feet	2·37 feet	2·19 feet
M_2	H*m*	1·32 feet	1·44 feet	1·60 feet	1·64 feet
	km	86°	80°	67°	16°
S_2	H*s*	0·69 feet	0·70 feet	0·68 feet	0·33 feet
	ks	124°	127°	93°	84°
K_2	H″	0·57 feet	0·55 feet	0·18 feet	0·09 feet
	k″	37°	60°	93°	84°
K_1	H′	0·13 feet	0·14 feet	0·19 feet	0·27 feet
	k′	302°	293°	124°	294°
P	H*p*	0·15 feet	0·16 feet	0·06 feet	0·09 feet
	kp	202°	186°	250°	294°
O	H_0	0·04 feet	0·04 feet	0·06 feet	0·06 feet
	k_0	76°	40°	124°	41°

The above table contains, in the 3rd and 4th columns, results worked out from data above, *i.e.* results obtained from two periods of seventy-four days each. The 5th column show the results over a period of thirty days worked out in 1887 by Mr. W. A. Finlay and printed in the Trans. of the Phil. Soc., vol. v, pt. ii (1886–89), pp. 254–258. The last column contains results worked out by myself in 1926 and stretching over a period of a fortnight. It will be seen that the first two columns agree very well in practically every constant except the K_2 amplitude, especially as regards the semi-mean ranges.

My thanks are due to General the Right Hon. J. C. Smuts, P.C., C.H., Sir William W. Hoy, Senator Dr. A. W. Roberts, Professor Morrison, Professor Andrew Young, Dr. Lawrence Crawford, Dr. J. S. van der Lingen, Mr. Spencer Jones, Mr. Charles Cochran, late Harbour Engineer, and the present Harbour Engineer, Mr. Shadwell and his Staff, for all assistance and encouragement rendered me in this research.

NOTE ON BRIOSCHI'S TREATMENT OF THE PRODUCT OF TWO SUMS OF EIGHT SQUARES.

By Sir THOMAS MUIR, F.R.S.

1. The paper of Brioschi's which concerns us here bears the title "Sur l'analogie entre une classe de déterminants d'ordre pair et les déterminants binaires," and appeared under date March 1855 in *Crelle's Journal*, lii, pp. 133–141. The fundamental result established in it is the fact that any even-ordered determinant is expressible as a pfaffian. This, however, the author views merely as a lemma: and having proved it he goes on, in the footsteps of Hermite, to his main business,—the consideration of a specially conditioned type of even-ordered determinant whose equivalent pfaffian has only a limited number of non-zero elements. One of this type it is that is utilised in dealing with the eight-square theorem.

2. Written exactly as Brioschi wrote it the determinant is

$$\begin{vmatrix} a & b & c & d & e & f & g & h \\ -b & a & -d & c & -f & e & -h & g \\ -c & d & a & -b & -g & h & e & -f \\ -d & -c & b & a & -h & -g & f & e \\ e & f & g & h & a & b & c & d \\ -f & e & -h & g & -b & a & -d & c \\ -g & h & e & -f & -c & d & a & -b \\ -h & -g & f & e & -d & -c & b & a \end{vmatrix}, \text{ or B say.}$$

If only as an aid to memory it is worth noting that its array of elements may be viewed as being composed of the two arrays

$$\begin{vmatrix} a & b & c & d \\ -b & a & -d & c \\ -c & d & a & -b \\ -d & -c & b & a \end{vmatrix}, \quad \begin{vmatrix} e & f & g & h \\ -f & e & -h & g \\ -g & h & e & -f \\ -h & -g & f & e \end{vmatrix}$$

each written twice, and that the said arrays are exactly alike in construction, the determinant of the one being the same function of a, b, c, d as the determinant of the other is of e, f, g, h, namely,

$$(a^2+b^2+c^2+d^2)^2 \quad \text{and} \quad (e^2+f^2+g^2+h^2)^2.$$

3. This observation, however, can fortunately be put to another use.

It enables us to apply to B a theorem, now formulated for the first time but already used by me in 1881 in connection with circulant arrays, and in 1888 in connection with unspecialised arrays by Gegenbaur (*Hist.*, iv, pp. 385, 391–392). The theorem is: *If* (P), (Q) *be the matrices of any two determinants of the* n^{th} *order, the* 2n-*line determinant*

$$\begin{vmatrix} (P) & (Q) \\ (Q) & (P) \end{vmatrix}$$

is expressible as the product of two determinants of the n^{th} *order*

$$|\ (P)+(Q)\ | \quad \textit{and} \quad |\ (P)-(Q)\ |,$$

in close analogy with the simple equality

$$\begin{vmatrix} p & q \\ q & p \end{vmatrix} = (p+q)(p-q).$$

4. Taking then in this for (P) and (Q) the two 4-line matrices drawn attention to above, we see that their sum and their difference are

$$\begin{matrix} a+e & b+f & c+g & d+h \\ -b-f & a+e & -d-h & c+g \\ -c-g & d+h & a+e & -b-f \\ -d-h & -c-g & b+f & a+e \end{matrix} \qquad \begin{matrix} a-e & b-f & c-g & d-h \\ -b+f & a-e & -d+h & c-g \\ -c+g & d-h & a-e & -b+f \\ -d+h & -c+g & b-f & a-e, \end{matrix}$$

and consequently that

$$B = \begin{vmatrix} a+e & b+f & c+g & d+h \\ -b-f & a+e & -d-h & c+g \\ -c-g & d+h & a+e & -b-f \\ -d-h & -c-g & b+f & a+e \end{vmatrix} \cdot \begin{vmatrix} a-e & b-f & c-g & d-h \\ -b+f & a-e & -d+h & c-g \\ -c+g & d-h & a-e & -b+f \\ -d+h & -c+g & b-f & a-e \end{vmatrix}.$$

A second piece of luck is that each of these 4-line factors of B is of exactly the same form as each of the simpler determinants whose values were given above. It thus follows that

$$B = \left\{(a+e)^2+(b+f)^2+(c+g)^2+(d+h)^2\right\}^2 \cdot \left\{(a-e)^2+(b-f)^2+(c-g)^2+(d-h)^2\right\}^2$$

or, if we write Σa^2 for $a^2+b^2+\cdots+h^2$ and M for $2(ae+bf+cg+dh)$,

$$\begin{aligned} B &= \{\Sigma a^2+M\}^2 \cdot \{\Sigma a^2-M\}^2 \\ &= \{(\Sigma a^2)^2-M^2\}^2, \end{aligned}$$

and not $(\Sigma a^2)^4$ as stated by Brioschi and as required by him for the validity of his proof.

5. The course to be taken in the face of this serious discrepancy need not be discussed: it has already received sufficient attention,* and the eight-square theorem has been firmly established otherwise. It is of more

* *Messenger of Math.*, xxxvii, pp. 107–111.

importance to know and appreciate the simple and secure basis on which rests our auxiliary theorem regarding the matrices (P) and (Q). Let us picture then to ourselves the $2n$-line determinant for which

$$\begin{vmatrix} (\mathrm{P}) & (\mathrm{Q}) \\ (\mathrm{Q}) & (\mathrm{P}) \end{vmatrix}$$

is an abridged notation, and let us perform on it the operations

$$\mathrm{row}_1+\mathrm{row}_{n+1},\quad \mathrm{row}_2+\mathrm{row}_{n+2},\quad \ldots\ldots,\quad \mathrm{row}_n+\mathrm{row}_{2n}$$

and convince ourselves that the result is, in the same notation,

$$\begin{vmatrix} (\mathrm{P})+(\mathrm{Q}) & (\mathrm{Q})+(\mathrm{P}) \\ (\mathrm{Q}) & (\mathrm{P}) \end{vmatrix};$$

next, on this let us perform the operations

$$\mathrm{col}_{n+1}-\mathrm{col}_1,\quad \mathrm{col}_{n+2}-\mathrm{col}_2,\quad \ldots\ldots,\quad \mathrm{col}_{2n}-\mathrm{col}_n$$

agreeing, as we should this time be readier to do, that the outcome is

$$\begin{vmatrix} (\mathrm{P})+(\mathrm{Q}) & . \\ (\mathrm{Q}) & (\mathrm{P})-(\mathrm{Q}) \end{vmatrix};$$

and, lastly, on this $2n$-line determinant with n^2 zero elements let us use Laplace's expansion-theorem, and we obtain the product of two n-line minors, one whose matrix is (P)+(Q) and the other whose matrix is (P)−(Q), or in symbols

$$|\ (\mathrm{P})+(\mathrm{Q})\ |\ .\ |\ (\mathrm{P})-(\mathrm{Q})\ |.$$

6. In similar fashion it may be shown that

$$\begin{vmatrix} (\mathrm{P}) & (\mathrm{Q}) & (\mathrm{R}) \\ (\mathrm{S}) & (\mathrm{T}) & (\mathrm{S}) \\ (\mathrm{R}) & (\mathrm{Q}) & (\mathrm{P}) \end{vmatrix} = \begin{vmatrix} (\mathrm{P})+(\mathrm{R}) & 2(\mathrm{Q}) \\ (\mathrm{S}) & (\mathrm{T}) \end{vmatrix} . \ |\ (\mathrm{P})-(\mathrm{R})\ |$$

in close analogy with

$$\begin{vmatrix} p & q & r \\ s & t & s \\ r & q & p \end{vmatrix} = \begin{vmatrix} p+r & 2q \\ s & t \end{vmatrix} . \ (p-r);$$

that

$$\begin{vmatrix} (\mathrm{P}) & (\mathrm{Q}) & (\mathrm{R}) & (\mathrm{S}) \\ (\mathrm{T}) & (\mathrm{U}) & (\mathrm{V}) & (\mathrm{W}) \\ (\mathrm{W}) & (\mathrm{V}) & (\mathrm{U}) & (\mathrm{T}) \\ (\mathrm{S}) & (\mathrm{R}) & (\mathrm{Q}) & (\mathrm{P}) \end{vmatrix} = \begin{vmatrix} (\mathrm{P})+(\mathrm{S}) & (\mathrm{Q})+(\mathrm{R}) \\ (\mathrm{T})+(\mathrm{W}) & (\mathrm{U})+(\mathrm{V}) \end{vmatrix} . \begin{vmatrix} (\mathrm{P})-(\mathrm{S}) & (\mathrm{Q})-(\mathrm{R}) \\ (\mathrm{T})-(\mathrm{W}) & (\mathrm{U})-(\mathrm{V}) \end{vmatrix}$$

with a similarly simple anologue: and so on, the general result being that *Any determinant which is centrosymmetric with regard to a number* ($2\mathrm{m}^2$ *or*

$2m^2-m+1$) *of* n-*line matrices is resolvable into two determinant factors exactly as if each of the matrices consisted of only one element.*

7. When the number of matrices is $2m^2$ they may be so increased in dimension as to be reduced in number to two, and the original theorem of § 3 be applicable. For example, taking $m=2$, so that the number of matrices is 8 as in the second instance of the preceding paragraph, we obtain by transposition of rows and of columns

$$\begin{vmatrix} (P) & (Q) & (R) & (S) \\ (T) & (U) & (V) & (W) \\ (W) & (V) & (U) & (T) \\ (S) & (R) & (Q) & (P) \end{vmatrix} = \begin{vmatrix} (P) & (Q) & (S) & (R) \\ (T) & (U) & (W) & (V) \\ (S) & (R) & (P) & (Q) \\ (W) & (V) & (T) & (U) \end{vmatrix}$$

which last, if we denote the $2n$-line square matrices

$$\begin{matrix} (P) & (O) \\ (T) & (U) \end{matrix} , \quad \begin{matrix} (S) & (R) \\ (W) & (V) \end{matrix} \quad \text{by} \quad (M), \ (N) \ ,$$

becomes

$$\begin{vmatrix} (M) & (N) \\ (N) & (M) \end{vmatrix} ,$$

and thus by § 3 is equal to

$$| \ (M)+(N) \ | \ . \ | \ (M)-(N) \ | \ ,$$

and thence, by addition and subtraction of matrices, equal to

$$\begin{vmatrix} (P)+(S) & (Q)+(R) \\ (T)+(W) & (U)+(V) \end{vmatrix} \cdot \begin{vmatrix} (P)-(S) & (Q)-(R) \\ (T)-(W) & (U)-(V) \end{vmatrix} ,$$

as before.

8. In view of the close analogy, which we have above pointedly drawn attention to, it will be found interesting to recall the other types of *determinants with matrix elements* (or " block " determinants, as they have been called for shortness' sake), and to observe their properties in comparison with those of the corresponding simple determinants. The types are three in number,—Puchta and Noether's circulant, Voigt and Igel's skew, and Simandl's continuant. The literature of the first two will be found on reference to vols. iii, iv of my *History*. The third is too recent to be included there, but a fairly full account of the original paper will be found in the *Proc. Roy. Soc. Edin.*, xlvi, pp. 62–64.

RONDEBOSCH, SOUTH AFRICA,
2nd August 1928.

THE BREEDING HABITS AND LIFE-HISTORIES OF SOME OF THE TRANSVAAL AMPHIBIA.—II.

By Vincent A. Wager, M.Sc.

(With Plates VI–X, and five Text-figures.)

Phrynomerus bifasciatus, Smith.

Shortly after the description of certain tadpoles referred to *Rappia marmorata* was published in the Transactions of the Royal Society of South Africa, Vol. XIII, Pt. 2, Dr. Noble of the American Museum of Natural History, New York, and Mr. Hewitt of the Albany Museum, Grahamstown, wrote to the author pointing out the fact that the tadpoles which he had ascribed to this frog were characteristic of the *Engystomatidae* and, apparently, an error had been made in their identification.

Attempts were made to investigate the matter in the field, but the two following seasons were exceptionally dry and, on account of the drought, the vleis in which the frogs were in the habit of breeding had dried up. Nevertheless, during the second dry season a trip was made to the locality (Gravelotte, in the N.E. Transvaal), but not a frog of any kind was seen.

During January 1928, the season being a wet one, the locality was again visited, and this time with complete success. It was found that the eggs which had been attributed to *Rappia marmorata* were laid by *Phrynomerus bifasciatus*, two pairs of frogs being caught in the act of laying them.

The author regrets that this error in identification was made, and is pleased to be able to rectify it here. The mistake arose through the fact that the young tailed frogs had discs on their toes, and their colouring, as well as their markings in the form of stripes on the back, were so very similar to the adult *Rappias* of which there were always large numbers around the pools. Another fact is that no specimens of *Phrynomerus bifasciatus* were seen at the time, and the author's stay in the vicinity terminated without his finding the eggs in the act of being laid.

The pools also contained a large variety of tadpoles which were identified as belonging to *Chiromantis xerampelina*, *Bufo regularis*, *Kassina senegalensis*, *Phrynobatrachus natalensis*, *Xenopus laevis*, *Pyxicephalus adspersus*,

Pyxicephalus natalensis, and two unknown tadpoles, one of which is here described under *Hemisus marmoratum*, and the other will shortly be described under *Hyperolius sugillatus*, so that there were no tadpoles which could have belonged to *Rappia marmorata*.

Thus the eggs and tadpoles which were described for *Rappia marmorata* belong to *Phrynomerus bifasciatus*, and to complete the life-history of this frog, a few notes are given below on its breeding habits.

Note on the Breeding Habits of *Phrynomerus bifasciatus* (Plate VI, figs. 1 and 2).

The eggs are probably laid well before daylight; for, although large numbers of newly laid egg-clusters were seen, only in one instance were the frogs discovered laying their eggs, and this was at dawn one morning after a heavy rainstorm. The frogs could be heard in hundreds in the close vicinity of the water, but they were very difficult to find. Their call is very characteristic, and can be heard for over half a mile. It consists of a very shrill, high-pitched pr-r-r-r, followed immediately by the same trill in slightly lower tone. Even when enclosed in a box the frog will emit its call. Newly laid eggs are usually found only on the day following a heavy rain, although the frogs can be heard calling incessantly in the neighbourhood of the pans for three or four nights afterwards.

It was noticed that these frogs also had the power of changing their colour. When kept in light surroundings for a few hours, the broad bands of vivid scarlet along the sides and over the caudal region may change to brick-red, pink, white, or even faintly yellow.

The frog seldom jumps but usually walks or runs. It has the same habit of burrowing as *Breviceps*, and the two frogs have often been found in loose sand under the same rocks and stones on hillsides many miles from the nearest water.

Note on *Hyperolius* (*Rappia*) *marmoratus*, Rapp. (Plate VII, figs. 1 and 2).

These little frogs were again found very commonly in the vicinity of the pans. Their vivid colouring affords them no protection, and in fact makes them conspicuous against a green background of foliage. It may be that this vivid colouration serves as a means of attraction for passing insects. They do not seek any shelter from the sun, but sit out in the open on the upper side of a leaf, on a twig, or on the side of a reed or blade of grass. On several occasions individuals were observed sitting exposed to the intense rays of the subtropical sun throughout an afternoon without

moving and apparently not in the least discomfited by the heat. One frog was noticed on a certain twig early one afternoon and was found in the identical position the following morning.

Numbers of young frogs of this species, each about a quarter of an inch in length, were also observed sitting on leaves on the edge of the pools, but neither the eggs nor the tadpoles were found. This was rather surprising, for after each rain the frogs collected in large numbers around the pools, and every leaf, twig, or blade of grass overhanging or in the water was examined carefully without any indication as to the breeding habits of this frog being obtained.

Hemisus marmoratum, Peters.

Specimens collected at Blackhills, Gravelotte, N.E. Transvaal, January 1928.

Distribution.—The species has been reported rarely from Gambia and Egypt southwards to Portuguese East Africa and Southern Rhodesia. Gravelotte is the most southern record at present known.

Habitat.—The country in which these frogs were found by the author is fairly flat and is typical Lowveld. The vegetation is subtropical in nature, and trees of which the Mopani (*Copaifera mopane*) is the dominant feature grow closely together. The only water in the neighbourhood is found in vleis or occasional pools along the dry sandy beds of the rivers. These rivers only contain running water for a few days after a heavy rain and for the rest are merely dry dongas. Numerous small vleis or pans occur usually in the neighbourhood of the rivers. These fill up with the spring rains, but very often do not last longer than five or six weeks, often less. Some of the larger pans, and the smaller ones in fairly wet seasons, may remain full till the end of autumn. The pans are well patronised by all manner of frogs after a rain, but one seldom sees a tadpole in any of the river pools.

Adult Frogs (Plate VIII, figs. 1 and 2).

The females are approximately $1\frac{1}{2}$ inches in length and are of a dark brown mottled colour over the head, back and top of the fore and hind limbs, with a faint yellowish or greenish tinge. The underside of the body and legs is white except for a faint brown discolouration under the throat. The small beady, black eyes are very prominent; the tip of the pointed snout is very hard and horny, and the mouth is situated on the underside of the head.

The males are smaller than the females, being only 1 inch in length. They have the same marking as the females except for a dark brown

colouration under the throat. The skin of the throat bulges out, forming a large vocal sac, but the frogs were never heard calling.

All the specimens that were obtained were found in burrows under the surface of the soil. Lang,* however, mentions that he found them in large numbers on the surface after rains.

When unearthed, the frogs were very quick in their movements and invariably made a dash for the water. When let loose on hard soil they moved in quick, short jumps, and often ran. If the soil was soft they would immediately attempt to dig themselves in. With up-and-down movements of the head, a hole would be forced into the soil, and with a liberal amount of pushing with the hind legs they soon burrowed out of sight. While hunting for them, large numbers of tunnels were found in the soil, and it seems probable that part of their food consists of worms encountered while burrowing.

Breeding Habits.—The eggs of this frog are laid in a nest dug in the soil in the form of a spherical cavity about 2 inches in diameter with well-smoothed walls (Plate IX). The nests may be any distance from 3 inches to 18 inches from the edge of the water, but they were most commonly found at a distance of about a foot therefrom. In most cases the top of the nest was a few inches below the surface of the soil; but on shelving banks they were deeper. One nest was found about 8 inches below the surface of the bank and 18 inches from the water. Cool spots, shaded by shrubs or trees, where grass grows profusely, or where the soil is covered with a liberal amount of dead foliage, are specially favoured by the frogs for their nesting sites. Nest-building begins after heavy rains, when the soil has become soft and muddy, and in such sheltered spots it is liable to remain wet for a considerable time.

In one instance the male and female frogs were found in a newly completed nest before the eggs were laid. The male was tightly clasping the female with his fore-legs just in front of her hind legs, and would not relinquish his hold. In fact, the two frogs remained in embrace for over ten days while they were being observed in captivity. When the pair was placed on soft, wet soil, the female, after taking a few hasty, short jumps, began to burrow rapidly, forcing her snout into the soil and pushing with her hind legs. The male held on doggedly and blindly all the while, and, taking no interest in the proceedings, was soon dragged out of sight into the newly formed burrow. It would seem as though mating took place above ground, the frogs leaving their burrows and congregating in pools after rains.

* Contributions to the Herpetology of the Belgian Congo, based on the Collection of the American Museum Congo Expedition, 1909–1915. By G. K. Noble, in Bulletin of the American Museum of Natural History, vol. xlix, Art. 11, p. 283 (1924).

A few males were found in burrows in close proximity to the nests, while a few others were unearthed a considerable distance away from the nests.

The female, however, was always found in the nest sitting with her legs touching the floor of the cavity, and the underside of her body resting on the eggs. This is one of the few cases of maternal instinct found in frogs, as the female takes care of the eggs until they are hatched. In two cases, old empty nests were found, and, although there were no visible remains, a tunnel could easily be traced where the soil was soft, wet and muddy, leading in a line through the bank to the water and entering the water some short distance below the surface. The newly hatched tadpoles are lively and indefatigable wrigglers, and, when this stage in their life is reached, it seems certain therefore that the mother burrows towards the water making a tunnel down which the tadpoles wriggle in a squirming mass until they reach the water. On entering the water the tadpoles immediately swim off in all directions, and the mother's responsibility is over.

The Eggs.—The eggs are laid in a white, solid, compact mass about an inch in diameter and half an inch thick (Plate IX). The mass can be picked up without the eggs becoming separated from one another, but individual eggs are soft and squash very easily. The egg-mass contains between 150 and 200 eggs. They are perfectly white in colour, and each is approximately 2 mm. in diameter. Each egg is enclosed in a clear gelatinous capsule 3 to 4 mm. in diameter.

Incubation.—Two. egg-masses which appeared to be newly laid were unearthed and each was placed in an artificial nest formed in wet mud in a small tin. In this manner the eggs and developing tadpoles could be studied under fairly natural conditions.

After five days the form of the developing embryo was discernible in the egg.

In each mass, between the eighth and ninth days, the tadpoles showed strong wriggling tendencies, and some began to break out of the egg capsules.

By the following day, the majority of the tadpoles had hatched out. From the moment of hatching, each tadpole commenced a slow wriggling action, so that the whole lot formed a fairly compact squirming mass. The remains of the jelly capsules had become fairly liquid, this slimy substance keeping the tadpoles in a moist condition.

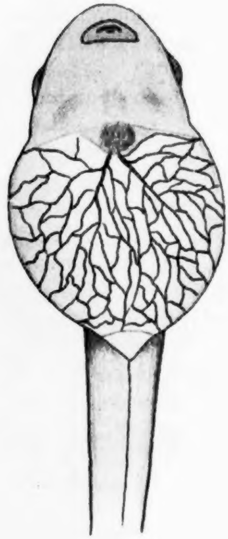
At this stage half of the tadpoles (*b*) were placed in water, the remainder (*a*) being left in the damp condition in the artificial nest.

Description of newly hatched Tadpoles.

The body is 3 mm. and the tail 6 mm. long. The yolk sac is very prominent, being white and 2 mm. in diameter. The lips are visible, but

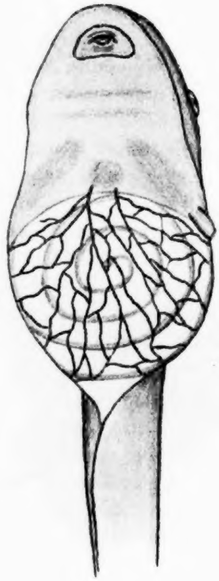
there is no mouth present. A peculiarity of this tadpole is the absence of suckers.

Mode of Respiration.—The mode of respiration in these young tadpoles is very remarkable, and appears to differ from that of other types of tadpoles,



del. V. A. W.

TEXT-FIG. 1.—*Hemisus marmoratum*: tadpole two days old, showing network of blood-vessels, ventral view. ($\times 15$ diam.)



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TEXT-FIG. 2.—*Hemisus marmoratum:* tadpole four days old, ventral view. ($\times 15$ diam.)

for no external gills are formed. A very well-developed system of blood-vessels can be seen covering the ventral surface of the body. When viewed with a binocular, these blood-vessels show up prominently against the white yolk (text-figs. 1, 2). This network of blood-vessels being so close to the surface of the skin, apparently acts in the same manner as lungs or gills, for the tadpole thrives just as well whether in the water or out of it.

Tadpoles Three Days old.

(a) *Tadpoles in Damp Nest.*—Body measures 4 mm. and tail 8 mm. in length. A few thick, white coils of intestine are present, and the network of blood-vessels on the ventral surface of the body-wall is very pronounced. The black jaws of the mouth are visible.

(b) *Tadpoles in Water.*—These are the same size as the others, but they appear to be in a further advanced condition. The spiracle is present on the left side, and the mouth and a few rows of teeth are apparent. Internal gills are present, and are slowly beginning to function, for very occasionally water passes in through the mouth. Blood-vessels still profusely cover the ventral body-wall.

Tadpoles Six Days old.

(a) *In Nest.*—Body is 4 mm. and tail is 9 mm. long. The tadpoles are looking rather thin, but the intermittent wriggling movement is maintained. The large number of blood-vessels on the body-wall is still very pronounced.

(*b*) *In Water.*—Body is 5 mm. and tail is 10 mm. long. The intestine now has many coils and in part still contains the white remains of the yolk. Only a few blood-vessels are left on the ventral body-wall.

Tadpoles Ten Days old.

(a) *In Nest.*—These show no change from those of six days old, except that they look very thin and emaciated. The blood-system on the ventral body-wall is still very well developed.

(b) *In Water.*—The underside of the body is becoming pigmented and opaque and very few blood-vessels are visible.

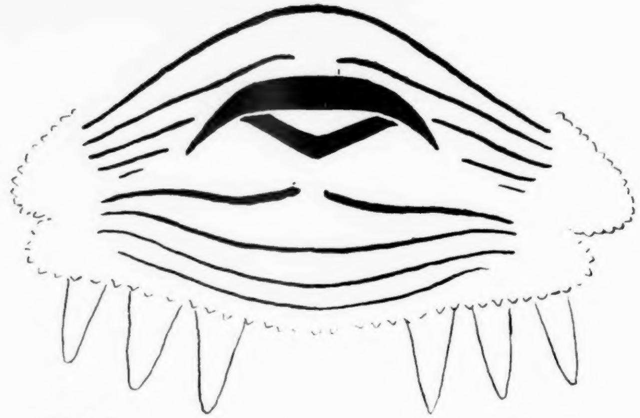
Tadpoles Seventeen Days old.

(a) *In Nest.*—The tadpoles look extremely thin, they exhibit no signs of moving, and are apparently dead. When placed in water, however, they wriggled convulsively and slowly revived.

These observations show the surprising fact that the newly hatched tadpoles, if kept in a moist condition, are capable of living, by means of this remarkable system of respiration, for eighteen days out of the water.

Description of Older Tadpoles.

When the tadpoles are about 20 mm. long they begin to exhibit the peculiar and characteristic marking of the tail as shown in text-fig. 5, and Plate X, figs. 1 and 2.



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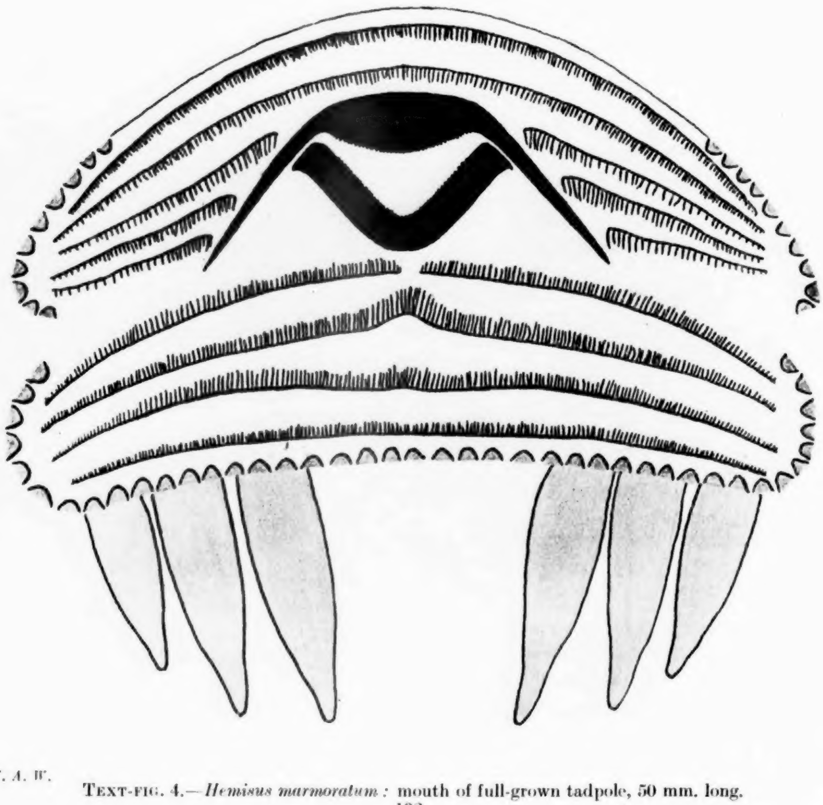
TEXT-FIG. 3.—*Hemisus marmoratum:* diagram of mouth of young tadpole, 20 mm. long.



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TEXT-FIG. 4.—*Hemisus marmoratum:* mouth of full-grown tadpole, 50 mm. long.

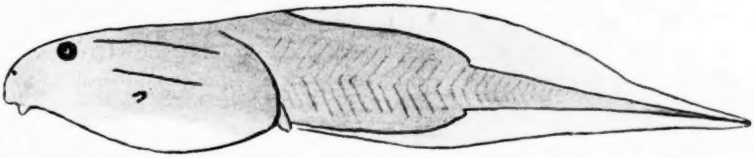
When the hind legs begin to show as tiny buds, the tadpole is approximately 40 mm. long, the body being slightly more than half as long as the tail.

Full-grown Tadpoles.

The maximum length of the tadpoles is about 52 mm., the tail being twice as long as the body.

The top of the head between the eyes is slightly rounded, and the eyes are situated on the sides of the head so that the lenses are vertical.

The distance between the end of the snout and the eyes is approximately one-quarter the distance between the snout and the end of the body. The anus is situated slightly to the right of the midline. The spiracle is on the



a

del. V. A. W. *b*

TEXT-FIG. 5.—*Hemisus marmoratum*: *a*, lateral, and *b*, dorsal views of full-grown tadpole. (×2 diam.)

left side of the body, midway between the mouth and anus, as shown in text-fig. 5.

Mouth.—There are two complete and three divided rows of horny teeth on the upper lip, and four complete rows on the lower lip, as shown in text-fig. 4. The number of teeth in the different rows is roughly as follows: Upper lip, first row, 180; second row, 150; third row, 80; fourth row, 80; fifth row, 50. Lower lip, first row, 160; second row, 180; third row, 180; fourth row, 190. A single row of small papillae surrounds the lower lip and extends partly up each side of the upper. A constant feature of the mouth in large and small tadpoles is the presence of six extra papillae. These are large, pendent from the lower lip, and arranged three on each side as shown in the figure.

Tail.—The tail is the same width as the body, *i.e.* 9 mm., and retains this width for one-third of its length, when it tapers rapidly to the tip.

The anterior portions of the upper and lower crests, to the extent of one-third or one-half of the length of the tail, is slightly thickened basally and deeply pigmented (text-fig. 5, and Plate X, figs. 1 and 2). This gives a very characteristic appearance to the tail, and is a considerable aid in the identification of the tadpoles, especially in the field.

Colouration.—The tadpoles are a dark brown mottled colour over the head and body. This colouration fades away to the sides, and the ventral surface of the body and neck is white. In some tadpoles the throat is a very light brown colour, in others it is a darker brown. The majority of tadpoles have a thin white line running from the tip of the snout over the back as far as the point of origin of the upper tail crest. Two other thin white stripes are present running parallel to the first, one on each side of the head and starting at the upper edge of the eye. Some tadpoles have no stripes at all, others only the two outer ones, while others have all three and two more, one on each side starting from the lower edge of the eye.

The thickened anterior portion of the tail has also the same dark brown mottled colour as the body.

In most of the tadpoles the crests of the tail are lightly dotted with brown pigment, but in others the crests are covered with dark brown blotches.

The tadpoles are very quick in their movements and dart about very rapidly when disturbed. They move very slowly while feeding and often remain motionless for considerable periods. Their food consists mostly of microscopic organisms which are scraped off stones and sticks, but the tadpoles are also very fond of chewing the stems and leaves of water-plants. A portion of the contents of the intestine of one tadpole was examined and found to contain large numbers of *Euglenae*, a few *Volvox* and *Pandorina* colonies, many different-shaped zygospores of *Conjugatae algae*, and numbers of desmids, diatoms, and pieces of algal filaments.

Metamorphosis.

Tadpoles which were raised from eggs in an aquarium had only reached the length of 35 mm. in three months ; under natural conditions, with a plentiful supply of proper food, the time taken to reach the terrestrial stage is probably about six weeks. After the fore-legs appear, the tadpole quickly undergoes its metamorphosis. The horny jaws and rows of teeth disappear, the mouth grows larger, and the head becomes very pointed. Very few four-legged tadpoles were found in the water, for when this stage is reached they crawl up the bank and hide under dead leaves while the tail is slowly absorbed. If the young tailed frogs (Plate X, fig. 3) are placed in water they very soon drown. When the tail is nearly absorbed, the young frogs,

which are exact replicas of the adults, start burrowing and commence their underground life.

It is interesting to note that the tadpole characters of *Hemisus* do not agree with the *Engystomatidae.* If the spiracle character is really of fundamental importance, *Hemisus* is more nearly related to the Ranidae.

The type specimens of this life-history, consisting of all stages from the egg to the adult, have been presented to the Albany Museum, Grahamstown, and the author wishes to thank Mr. John Hewitt for his advice and kindly help in the matter of identification.

Photo by V. A. Wager.

FIG. 1.—*Phrynomerus bifasciatus* : female. (Nat. size.)

Photo by V. A. Wager.

FIG. 2.—*Phrynomerus bifasciatus* : male and female. (Nat. size.)

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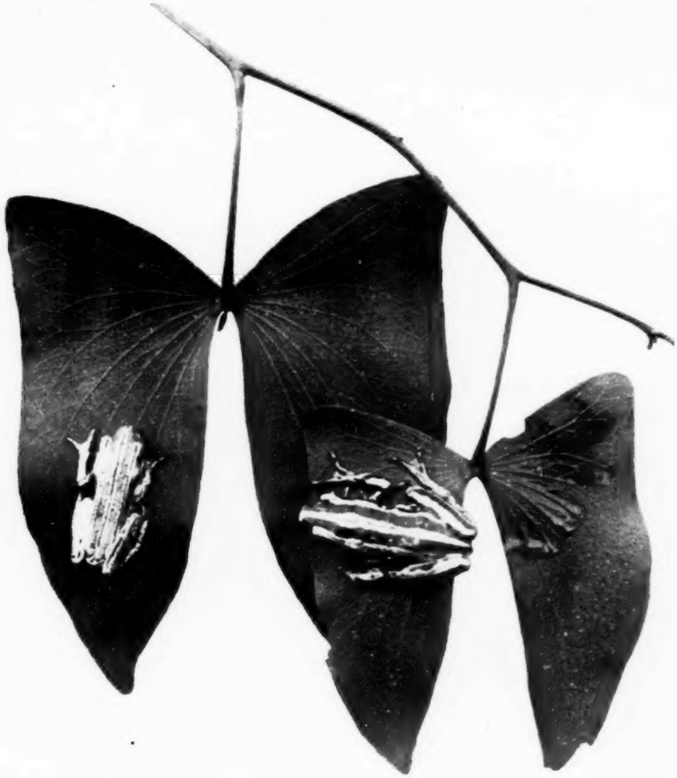

Photo by V. A. Wager.

Fig. 1.—*Hyperolius marmoratus* on Mopane leaves. (Nat. size.)

Photo by V. A. Wager.

Fig. 2.—*Hyperolius marmoratus.* (Nat. size.)

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FIG. 1.—*Hemisus marmoratum:* female. (Nat. size.)

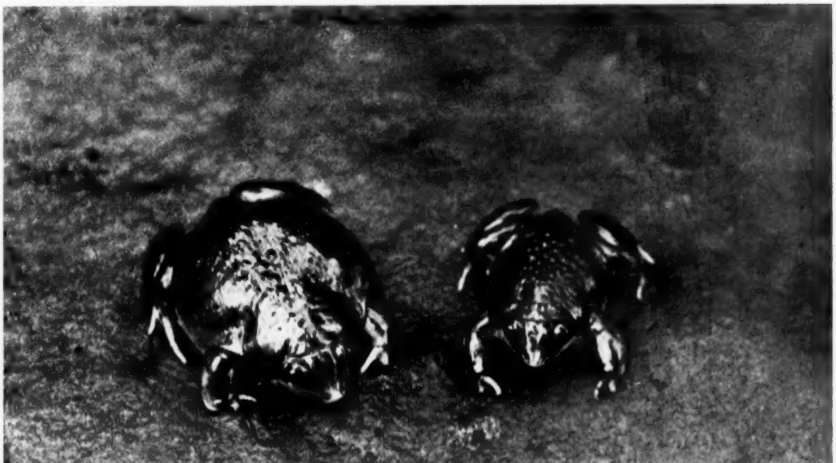

Photo by V. A. Wager.

FIG. 2.—*Hemisus marmoratum:* male and female. (Nat. size.)

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Hemisus marmoratum : section of a bank, showing nest and eggs. (Nat. size.)

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FIG. 1.—*Hemisus marmoratum* : full-grown tadpole. (Nat. size.)

Photo by V. A. Wager.

FIG. 3.—*Hemisus marmoratum* : young tailed frog. (Nat. size.)

Photo by V. A. Wager.

FIG. 2.—*Hemisus marmoratum* : full-grown tadpole. (Nat. size.)

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NOTE ON SUMS OF EQUIGRADE COAXIAL MINORS.

By Sir THOMAS MUIR, F.R.S.

1. In view of the recent revival of interest * in the subject of the coaxial minors of a determinant, it may be appropriate to bring to notice a whole class of determinants, as yet unstudied, in which the said minors play a prominent part. The problem in both cases is one of expressibility, the older (MacMahon's) seeking the expression of any determinant whatever by means of its coaxial minors in unconditioned order or collocation, the new seeking the expression of a specially derived determinant in terms of the *sums* of *equigrade* coaxial minors pertaining to the determinant initially used as base.

2. If Δ be any n-line determinant whose (r,s)th element is a_{rs} and whose m-line coaxial minors have the sum S_m, then the type of new determinant is

$$\left| \frac{\partial S_m}{\partial a_{rs}} \right| ,$$

and the problem is to express this in terms of S_1, S_2, . . . For example, taking the case where n is 4, and

$$\Delta = | a_1 b_2 c_3 d_4 | ,$$

and where consequently

$$\begin{aligned}
S_1 &= a_1+b_2+c_3+d_4, \\
S_2 &= | a_1b_2 | + | a_1c_3 | + | a_1d_4 | + | b_2c_3 | + | b_2d_4 | + | c_3d_4 | , \\
S_3 &= | a_1b_2c_3 | + | a_1b_2d_4 | + | a_1c_3d_4 | + | b_2c_3d_4 | , \\
S_4 &= | a_1b_2c_3d_4 | = \Delta,
\end{aligned}$$

we have four new derivative determinants available for consideration, namely,

$$\left| \frac{\partial S_1}{\partial a_1} \quad \frac{\partial S_1}{\partial b_2} \quad \frac{\partial S_1}{\partial c_3} \quad \frac{\partial S_1}{\partial d_4} \right| , \; . \; . \; . \; . \; . \; . \; . \; . \; , \quad \left| \frac{\partial S_4}{\partial a_1} \quad \frac{\partial S_4}{\partial b_2} \quad \frac{\partial S_4}{\partial c_3} \quad \frac{\partial S_4}{\partial d_4} \right| .$$

* Mainly due to Mr. E. B. Stouffer of Kansas, whose first paper on the subject appeared in 1922, and whose latest, entitled "Expressions for the General Determinant in Terms of its Principal Minors," is printed in the current number of the American Math. Monthly (xxxv, 1928, pp. 18–21).

3. Of the four, the first, as having the matrix unity, and the fourth, as being the adjugate of Δ, need not detain us. The second, Δ_2 say, is

$$\begin{vmatrix} b_2+c_3+d_4 & -b_1 & -c_1 & -d_1 \\ -a_2 & c_3+d_4+a_1 & -c_2 & -d_2 \\ -a_3 & -b_3 & d_4+a_1+b_2 & -d_3 \\ -a_4 & -b_4 & -c_4 & a_1+b_2+c_3 \end{vmatrix},$$

and this, if we write its diagonal in the form

$$S_1-a_1, \quad S_1-b_2, \quad S_1-c_3, \quad S_1-d_4,$$

suggests expansion according to powers of S_1, which being done gives us

$$S_1^4-S_1^3S_1+S_1^2S_2-S_1S_3+S_4 \qquad i.e. \qquad S_1^2S_2-S_1S_3+S_4$$

as desired.

4. The third for evaluation, Δ_3 say, is

$$\begin{vmatrix} |b_2c_3|+|b_2d_4|+|c_3d_4| & -|b_1c_3|-|b_1d_4| & |b_1c_2|-|c_1d_4| & |b_1d_2|+|c_1d_3| \\ -|a_2c_3|-|a_2d_4| & |c_3d_4|+|c_3a_1|+|a_1d_4| & -|a_1c_2|-|c_2d_4| & -|a_1d_2|+|c_2d_3| \\ |a_2b_3|-|a_3d_4| & -|a_1b_3|-|b_3d_4| & |a_1d_4|+|b_2d_4|+|a_1b_2| & -|a_1d_3|-|b_2d_3| \\ |a_2b_4|+|a_3c_4| & -|a_1b_4|+|b_3c_4| & -|a_1c_4|-|b_2c_4| & |a_1b_2|+|a_1c_3|+|b_2c_3| \end{vmatrix}$$

Here the immediate use of the artifice of the preceding paragraph affords no help. If, however, we multiply row-wise by $|a_1b_2c_3d_4|$ we obtain a product whose first row is

$$|a_1b_2c_3|+|a_1b_2d_4|+|a_1c_3d_4|, \quad |b_1c_3d_4|, \quad |c_1b_2d_4|, \quad |b_2c_3d_1|$$

or, in the usual short notation for the primary minors of $|a_1b_2c_3d_4|$,

$$D_4+C_3+B_2, \quad -A_2, \quad -A_3, \quad -A_4:$$

and the outcome from the other rows being similar, we have for our whole product

$$\begin{vmatrix} S_3-A_1 & -A_2 & -A_3 & -A_4 \\ -B_1 & S_3-B_2 & -B_3 & -B_4 \\ -C_1 & -C_2 & S_3-C_3 & -C_4 \\ -D_1 & -D_2 & -D_3 & S_3-D_4 \end{vmatrix}$$

which, on being expanded exactly in the manner of § 3, we find to be equal to

$$S_3^4-S_3^3S_3+S_3^2S_2S_4-S_3S_4^2S_1+S_4^3,$$

i.e.

$$S_4(S_3^2S_2-S_3S_1S_4+S_4^2),$$

and, therefore, on withdrawing the introduced factor, we have

$$\Delta_3=S_3^2S_2-S_3S_1S_4+S_4^2$$

as desired.

5. The peculiar initial step just taken in the evaluation of Δ_3, namely, the multiplication of Δ_3 itself by Δ, deserves special attention. It is not always so effectual, but it never fails to be of service. In illustration let us take the next higher case, where the basic determinant is $| a_1b_2c_3d_4e_5 |$, or E say. As before, it is manifest that $E_1=1$, and that E_5, being the adjugate, equals S_5^4. Next, E_2 is found exactly as D_2 was, the result being

$$E_2=S_1^3S_2-S_1^2S_3+S_1S_4-S_5\,;$$

and E_4, the penultimate, exactly as D_3 the previous penultimate was, the result being

$$E_4=S_4^3S_3-S_4^2S_2S_5+S_4S_1S_5^2-S_5^3.$$

When we come, however, to the remaining determinant of the set, E_3, there is difficulty: and multiplication of E_3 by E gives comparatively little help, as the product

$$\begin{vmatrix} S_3-\dfrac{\partial S_4}{\partial a_1} & -\dfrac{\partial S_4}{\partial a_2} & \cdots\cdots \\ -\dfrac{\partial S_4}{\partial b_1} & S_3-\dfrac{\partial S_4}{\partial b_2} & \cdots\cdots \\ \cdots & \cdots & \cdots\cdots \end{vmatrix}$$

is not more easily handled than the multiplicand itself. Only the close relation of the product matrix to the matrix of E_4 proves of assistance.

6. As a compensation, however, there is suggested by it the possible existence of a general multiplication-theorem; and this on examination is readily confirmed, and a formal proof obtained. The result may perhaps be best formulated thus: *If* S_m *be the sum of the* m*-line coaxial minors of any determinant* $| a_{rs} |_n$, *then*

$$| a_{rs} | \,.\, \left| \frac{\partial S_m}{\partial a_{rs}} \right| = \left| S_m - \frac{\partial S_{m+1}}{\partial a_{rs}} \right|,$$

it being understood that in the case of the determinant intended to be represented on the right it is only the diagonal elements that are augmented by S_m. A sufficient illustration is furnished by the first of the two suggesting cases, namely, the case in § 4 where n is 4 and m is 3. Of course, as a result of the theorem we have a second series of derived determinants expressible in terms of sums of equigrade coaxial minors.

7. Among the inquiries which naturally arise in regard to the new forms perhaps the most interesting is as to their own sums of equigrade coaxial minors. These, like themselves, we should expect to find expressible in terms of the original S's; and therefore, to avoid confusion with others, we cannot do better than recur to the lengthier notation which has the

advantage of specifying the determinant to which the particular S's belong, namely,

$$\mathrm{Saxm}_r\mathrm{X},$$

standing for the sum of the r-line coaxial minors of X. Thus the basic determinant being the Δ of § 2, and $\mathrm{Saxm}_1\Delta$, $\mathrm{Saxm}_2\Delta$, ... being as there S_1, S_2, ... , let us inquire as to the coaxial minors of Δ_1, Δ_2, ...

8. For Δ_2 (see § 3) there is no difficulty in ascertaining that the set of results is

$$\begin{aligned}
\mathrm{Saxm}_1\Delta_2 &= 3S_1,\\
\mathrm{Saxm}_2\Delta_2 &= 3S_1^2+S_2,\\
\mathrm{Saxm}_3\Delta_2 &= S_1^3+2S_1S_2-S_3,\\
\mathrm{Saxm}_4\Delta_2 &= S_1^2S_2-S_1S_3+S_4.
\end{aligned}$$

With Δ_3 (see § 4) the labour is of course considerably increased. There is, however, one at least of the results that is well worth the trouble of the calculation, because of the curious fact that it is exactly the same as one in the other derived series of determinants, the symbolic expression of the identity being

$$\mathrm{Saxm}_2\left|\frac{\partial S_3}{\partial a_1}\ \frac{\partial S_3}{\partial b_2}\ \frac{\partial S_3}{\partial c_3}\ \frac{\partial S_3}{\partial d_4}\right| = \mathrm{Saxm}_2\left|\begin{matrix} S_2-\dfrac{\partial S_3}{\partial a_1} & -\dfrac{\partial S_3}{\partial a_2} & \cdots\cdot \\ -\dfrac{\partial S_3}{\partial b_1} & S_2-\dfrac{\partial S_3}{\partial b_2} & \cdots\cdot \\ \cdots & \cdots & \cdots \end{matrix}\right|$$
$$=2S_4+S_3S_1+S_2^2.$$

An *à priori* proof of the first part of this could not fail to be of interest.

9. Another related result which it is desirable to formulate is one which we have implicitly used above as a lemma: namely, *If* S_1, S_2, S_3, ... , S_n *be the sums of equigrade coaxial minors of any* n-*line determinant, and* $\Sigma_1, \Sigma_2, \Sigma_3$, ... , Σ_n *be the corresponding sums in the case of the adjugate, then*

$$\sum\nolimits_1 = S_{n-1},\quad \sum\nolimits_2 = S_nS_{n-2},\quad \sum\nolimits_3 = S_n^2S_{n-3} = \ldots\ldots,$$

and therefore

$$\sum\nolimits_1+\sum\nolimits_2+\ldots\ldots+\sum\nolimits_n = (S_{n-1}, S_{n-2}, \ldots\ldots, S_1)(1, S_n, S_n^2, \ldots S_n^{n-1}).$$

RONDEBOSCH, S.A.,
25th August 1928.

THE TIME FACTOR IN THE CHROMATIC RESPONSES OF *XENOPUS LAEVIS*.

By David Slome and Lancelot Hogben.

(From the Department of Zoology, University of Cape Town.)

(With four Text-figures.)

1. Introduction.

In a previous communication (Slome and Hogben (1)) it has been shown by a statistical method based on assigning arbitrary numerical symbols to different stages of melanophore contraction :

(i) That, within a wide range of temperature (5°–30° C.), normal individuals of *Xenopus laevis* become dark if placed in light in a situation such that the field of vision is occupied by a surface which absorbs light (" black background "), and become pale if placed in light in a situation such that the field of vision is occupied by a surface which scatters and reflects light (" white background ").

(ii) That eyeless individuals do not display this type of reactivity, but, like normal animals subjected to prolonged exposure to total darkness, remain in an intermediate condition due to the partial expansion of the dermal melanophores.

(iii) That in eyeless animals the melanophores are slightly more expanded in light than in darkness, so that there is a " primary " reactivity of the pigmentary effector system independent of the eyes, tending in the opposite direction to the " secondary " co-ordinated response for which the eye is the receptor organ, and much less considerable in extent than the visual response.

(iv) Since the threshold of illumination for the " primary " reaction to light is higher than that for the secondary, the optimum condition for pallor in normal animals is dim light reflected from a light-scattering surface occupying the field of vision, while the optimum condition for darkening is a light-absorbing visual field with bright illumination from above.

It is not proposed in this communication to discuss the primary

reactivity which may depend (*a*) on direct response of the pigmentary effector organ to stimulus, or (*b*) a co-ordinated response for which the receptor is some photo-sensitive end-organ in the skin. The "secondary" reactivity on the other hand must involve a co-ordinating system which may be endocrine, nervous, or both, and the fact that eyeless animals are neither completely pale nor completely dark implies that the *white-background* and *black-background* response involve separate entities in the co-ordination of stimulus and response. Now this two-fold character of the co-ordination may be explained by either of two hypotheses (*a*) and (*b*), or a combination of both. The two hypotheses are :

(*a*) That there are two separate photo-receptive elements in the eye with different thresholds of excitation tending to produce in the one case inhibition, in the other case excitation, of the same mechanism of discharge (endocrine or nervous).

(*b*) That there are two separate mechanisms of discharge acting in opposite senses on the pigmentary effector, and that which predominates over the other is determined by the number of photo receptors stimulated.

For the purpose of clearer exposition it is proposed to call the mechanism of discharge underlying, on the second hypothesis, the white-background response W, and the mechanism of discharge underlying the black-background response B, and it may here be said that experimental evidence to be submitted at a later stage justifies the conclusion that B is identifiable with the secretion of the melanophore stimulant of the pituitary gland. A question which at once presents itself on the basis of the facts hitherto elicited is whether W is nervous or endocrine on the assumption that hypothesis (*b*) is correct, and a study of the time factor in the process was undertaken as an initial step. The further analysis of the visual response from this angle opens up the possibility of discriminating between hypotheses (*a*) and (*b*), as well as placing on record for the first time a quantitative treatment of this aspect of pigmentary effector activity. A study has therefore been made of the time relation involved in :

(i) Passing from the black- and white-background response to the intermediate phase in total darkness.

(ii) Transition to the white- and black-background response from the intermediate condition consequent on prolonged exposure to darkness.

(iii) Complete reversal of the white- and black-background response in both directions.

The results of the investigation will be considered in this order. But before proceeding it may be advisable to sound a note of caution. In interpreting these results, which are presented in graphical form, it must be borne in mind that the numerical symbols applied to different configurations of the dermal melanophores are quite arbitrary, and therefore,

though some insight may be obtained from a consideration of the intervals which elapse between equilibrium conditions and the intercalation of subnormal or supernormal phases, no significance can legitimately be attached to the gradients of the curves.

2. Transition to the Intermediate Condition in Darkness.

The first problem to be investigated was the time taken by dark and pale animals to reach the intermediate condition in complete darkness.

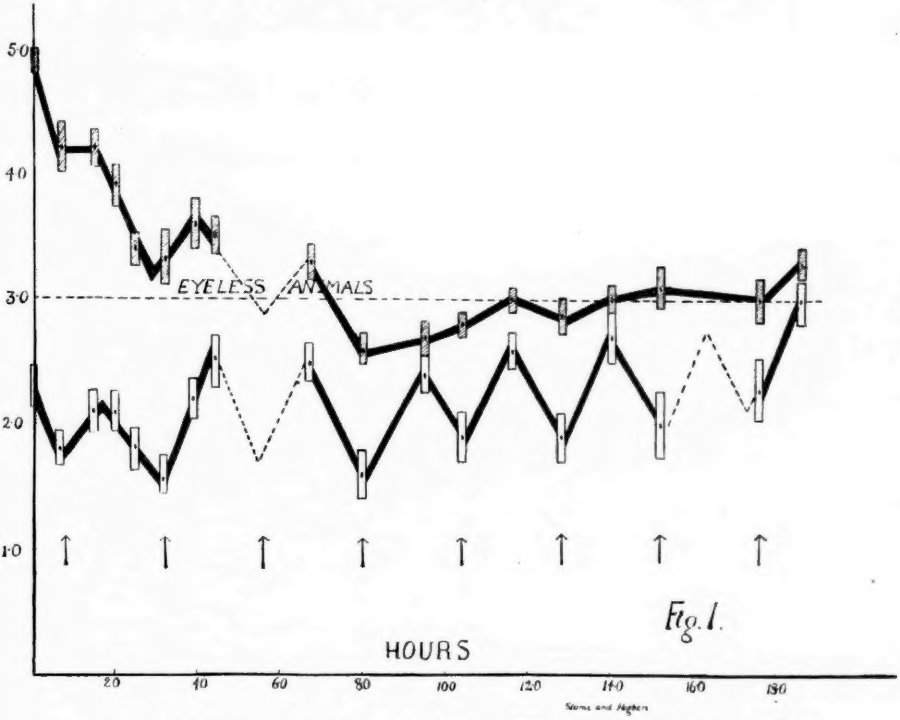

Fig. 1.—Dark-room experiment at 22° C. Upper series toads in black containers (originally dark). Lower series originally pale toads in white containers. Margin of error, standard deviation of mean of each series. The arrows represent twenty-four hour intervals (midnight to midnight).

Previous experience had shown that this was considerable, and that pale toads required a more protracted exposure to darkness than dark ones before equilibrium was established, *i.e.* the eyeless condition was attained. In

the first experiment (fig. 1) eleven pale toads in white pots and eleven dark toads in black pots were placed in a large light-proof and well-ventilated box in the dark-room. The use of the box disposed of the necessity of exposing any individual to light for more than a few seconds when observations were taken. In this experiment there are three significant features which at once emerge from the graphical record. First, that the dark animals attain the eyeless equilibrium much more readily than the pale ones. Second, that there is a decided tendency for the melanophores to be more contracted at midnight, suggesting a diurnal variation analogous to that recorded for the primary photic reaction of Crustacea by Keeble and

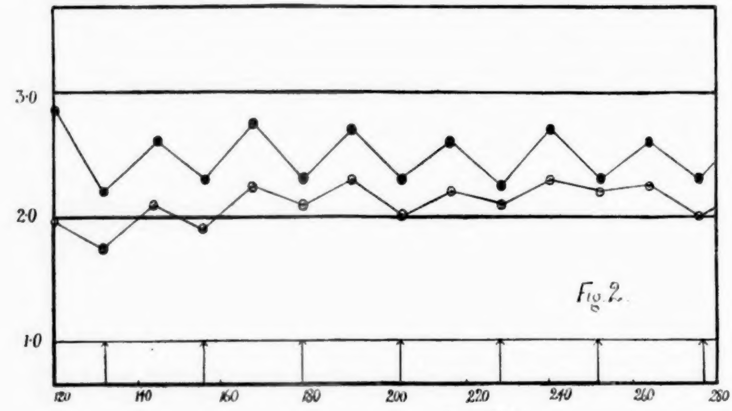

FIG. 2.—Part of an experiment showing transition from pale (lower) and dark (upper) condition to the intermediate state in darkness. It is inserted to show the regular diurnal variation. Arrows twenty-four hour intervals (midnight to midnight).

Gamble (2). Third, that dark animals, after reaching the intermediate condition within 40 to 50 hours, become considerably paler than the eyeless animal, and remain so until about 120 hours after beginning of experiment, that is to say, they do not settle down to the eyeless equilibrium condition till about the same time as the toads which were initially pale. To obtain further confirmation on the last two points, *i.e.* the diurnal variation and the subnormal phase of the initially dark toads, the experiment was repeated at a different temperature. In the second experiment twelve toads in each series were employed, initially pale animals being placed in black pots and initially dark animals in white pots immediately before placing in the dark-room. In this second experiment the time required to attain equilibrium on the part of the initially pale toads was even more protracted than in the first. A part only of the experiment is reproduced,

but the diurnal variation was consistent throughout the entire series of observations (fig. 2). Now, while the variation is not significantly outside the range of probable error for two successive points on the curve, the complete consistency of the two curves, and the perfect regularity of the result, leave no doubt as to the authenticity of this diurnal change, which it is not without interest to note is in the same sense as the normal diurnal rhythm resulting from the primary response, and thus suggests that the mechanism involved is a "conditioned" one in Pavlov's terminology. In the second experiment the subnormal phase of the initially dark toads was quite pronounced, and complete equilibrium of the initially pale animals took about a fortnight.

3. Transition from Darkness to White and Black Background.

Two experiments were carried out on the same two series of animals as were employed in those represented in figs. 1 and 2. Fig. 3 is a continuation of fig. 1, the origin being taken as the point of illumination to continuous diffuse artificial light. On a black background the animals attain their final equilibrium in about an hour, surpass it seemingly, and then settle down to their final equilibrium about the time when the series placed on white background attained maximum pallor asymptotically—25–30 hours after the beginning of the experiment. In a repetition of this experiment on the second series of individuals to ascertain whether the apparent existence of a supernormal phase on the series placed on black backgrounds was the fortuitous result of reinforcement by the diurnal variation, the existence of the supernormal phase was very decisively confirmed, as the following protocol makes evident.

Time.		White background.	Black background.
hr.	min.		
0	00	2·7 ±0·22	2·5±0·19
1	50	2·75±0·18	3·5±0·15
3	00	2·5 ±0·19	4·1±0·15
4	00	2·4 ±0·14	4·2±0·16
5	30	2·3 ±0·13	4·4±0·15
6	55	2·18±0·16	4·4±0·15
7	55	2·18±0·10	4·6±0·14
21	25	2·0 ±0·00	4·5±0·15
24	55	2·0 ±0·00	4·4±0·19
Equilibrium value 150 hours		1·9 ±0·08	4·25±0·12

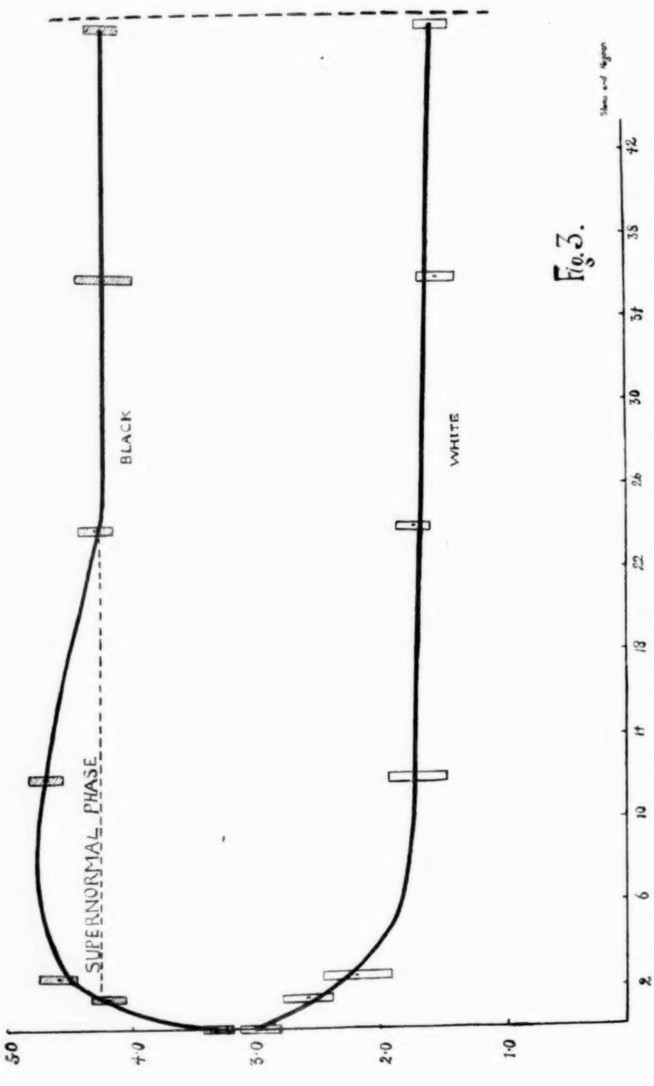

FIG. 3.—Transition from intermediate condition in darkness to dark and pale condition in light. Upper series blackened containers, lower series white. Temperature 22° C.

It is worth while pausing at this point to compare the time relations of the transition from darkness to white and black background respectively, and the reverse operation as recorded in the preceding section. From these experiments it is seen that the time taken to reach equilibrium in passing from the black-background equilibrium to the intermediate state is significantly greater than in the reverse process, viz., in passing from the intermediate condition characteristic of equilibrium in darkness to the black-background response in light.

It is further seen that the time taken to pass from the white-background equilibrium to the intermediate condition in darkness is significantly greater than the time taken to pass from the intermediate condition in darkness to white-background equilibrium in light. Finally, it is seen that the time required to pass from black-background equilibrium to the intermediate condition is much less than the time required to pass from the white-background equilibrium to the intermediate condition in darkness. Also that the time required to pass from intermediate condition in darkness to black-background equilibrium in light is less than the time required to pass from intermediate condition in darkness to white-background equilibrium in light. These conclusions may be epitomised by the aid of the following symbolism, where b, w, and i represent respectively the equilibrium conditions for black background, white background, and darkness, the arrows the direction of the process, and the usual conventions for inequalities being employed.

$$b \longrightarrow i > i \longrightarrow b$$
$$w \longrightarrow i > i \longrightarrow w$$
$$b \longrightarrow i < w \longrightarrow i$$
$$i \longrightarrow b < i \longrightarrow w.$$

These results are totally inexplicable in terms of hypothesis (a) set forth in the introduction, and the existence of two separate mechanisms of discharge is reinforced by the existence of the subnormal and supernormal phases. For, if mechanisms B and W are both brought into play when the eye is illuminated, the final result depending on the number of photo-receptors stimulated, the slower rate at which W subsides would necessitate a subnormal phase in passing from black background in light to darkness, while the slower rate of development of W would necessitate a supernormal phase in passing from the intermediate condition in darkness to the black-background equilibrium.

4. Reversal of Background Response.

There remains to consider what happens when animals which have attained the white-background equilibrium are transferred to a black

background and vice versa. Here, as before (see fig. 2), mechanism W comes into play much more slowly than mechanism B; in other words, equilibrium is reached more rapidly in passing from white to black than from black to white. But, as would be expected, it takes much longer to attain equilibrium in passing from these extremes than in passing from the intermediate state to either condition. Not only is this the case, but

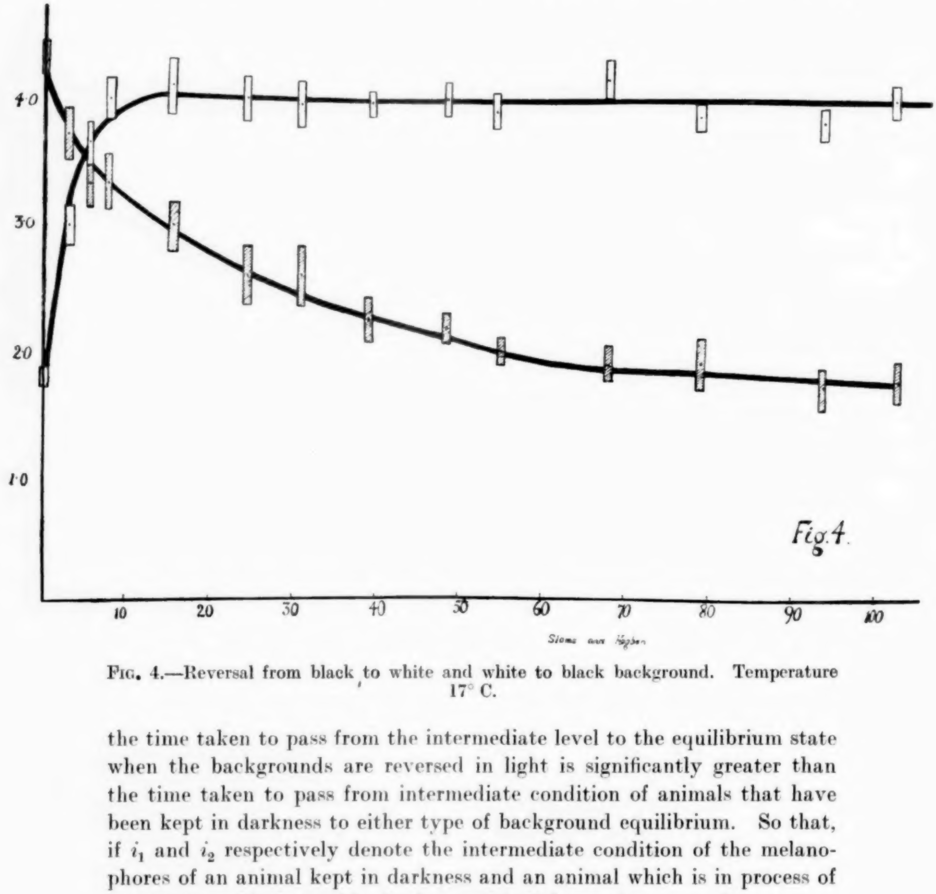

Fig. 4.—Reversal from black to white and white to black background. Temperature 17° C.

the time taken to pass from the intermediate level to the equilibrium state when the backgrounds are reversed in light is significantly greater than the time taken to pass from intermediate condition of animals that have been kept in darkness to either type of background equilibrium. So that, if i_1 and i_2 respectively denote the intermediate condition of the melanophores of an animal kept in darkness and an animal which is in process of passing from black to white background in light or vice versa, then

$$i_2 \longrightarrow w > i_1 \longrightarrow w,$$

and

$$i_2 \longrightarrow b > i_1 \longrightarrow b.$$

On the other hand, it takes less time to pass from white-background equilibrium to the black-background equilibrium in light than it does to pass from the white background to the intermediate equilibrium in darkness or $w \longrightarrow b < w \longrightarrow i_1$. And on the hypothesis of two separate efferent mechanisms B and W, this result is again explicable, since the first reaction involves the subsidence of W only, whereas the second result involves the subsidence of W and the subsidence of B.

Two experiments were performed and the results were perfectly consonant. Fig. 4 is based on the same series of animals as those used in the experiment on which fig. 2 is based. It will be noticed that there is no supernormal phase in passing from white-background equilibrium to black-background equilibrium, and this would be expected in terms of hypothesis *b* that may now be formulated in more explicit terms.

5. Conclusion.

The entire series of data here presented are, it is submitted, incompatible with the hypothesis that a single efferent mechanism, viz., the fluctuating secretion of the melanophore stimulant of the pituitary gland, underlies the background response of *Xenopus* and, it may be added, of other Amphibia. There may or may not be two sets of receptors whose activation tend to produce opposing results. For the present it is an economy to assume that the number rather than quality of receptors brought into play is the significant factor. But, in any case, there must be separate efferent mechanisms—using the term efferent without restriction as to the endocrine or nervous character of the process—underlying the white- and black-background responses. It would then be possible to outline a working hypothesis in some such terms as these. When an animal kept in total darkness for some time is placed on a black background the small amount of light reflected stimulates some photo-receptors, bringing into play mechanism B, *i.e.* increased output of pituitary secretion, and mechanism W at present unknown. At first the effect of B overrides W, but as more photo-receptors are brought into play, *i.e.* when the field of vision is occupied by a light-scattering surface, the output of B reaches a limit before W, so that W overrides B. Alternatively the small amount of light reflected from a light-absorbing surface may inhibit W more than B, but as more receptors are brought into play the inhibition of B becomes more complete than the inhibition of W.

In any case the salient points which emerge from the study of the time relations of pigmentary effector activity of *Xenopus* point to the following conclusions. First, that a different efferent mechanism, endocrine or nervous, underlies the black- and white-background responses of the

intact animal. Second, that the protracted development of both types of response is consistent with an endocrine rather than a nervous mechanism. Thirdly, the existence of a diurnal variation in darkness, comparable in extent and direction to the normal diurnal rhythm of primary reactivity, is suggestive of the intervention of nervous agencies in the primary reaction.

In a later communication more direct evidence will be presented in support of these conclusions. For the present it may be remarked that (*a*) the effects of extirpation and injection suffice to identify mechanism B with the activity of the posterior lobe of the pituitary gland; (*b*) the removal of the anterior lobe of the pituitary gland alone abolishes the white-background response, removal of the pineal gland does not; (*c*) the primary reactivity is not affected by removal of either the anterior lobe of the pituitary or the whole gland.

The expenses of this research were defrayed by a grant from the Government Research Grant Board.

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(2) Keeble and Gamble, Phil. Trans. Roy. Soc., B, vol. cxcvi–cxcviii.
(3) Hogben, Pigmentary Effector System. Oliver & Boyd.

MATERIALS FOR A CRITICAL REVISION OF CRASSULACEAE.

(THE SOUTH AFRICAN SPECIES OF THE GENUS *CRASSULA* L. (EMEND. SCHONL.).)

By S. SCHONLAND.

INTRODUCTION.

In the present paper I have set myself chiefly three tasks—(1) to arrange the known South African species of *Crassula* into, what I consider to be, natural groups with hints on their possible phylogeny; (2) to give their geographical distribution; (3) to unravel the complicated synonymy. A number of new species are described, and notes on many of the older species are given. The synonymy is extremely difficult to deal with, and I may claim to have made considerable progress with it.

Like other succulents, when dried for herbarium purposes, Crassulas often lose some of their essential characters, and consequently the study of these plants from dried specimens is very difficult and frequently unsatisfactory. If to this is added that many species, especially those of the older authors, were very incompletely characterised and that many were described from specimens grown in Europe under unnatural conditions, the difficulty of recognising these species will be at once apparent.

Even under natural conditions in South Africa many species vary greatly, especially in their vegetative organs, as well as in their inflorescences, and to a slight extent even in the flowers. Hybrid forms appear to be very rare.

I have seen most of the material preserved in South African herbaria. I also had the privilege to study the general collections of Crassulas at Kew, the British Museum, Berlin, Oxford, and Paris.* Amongst the collections made in the eighteenth century I have seen those of Dillenius

* To the heads of the institutions who have allowed me to study their material, and to the members of their staffs who have facilitated my work, I wish once more to make my grateful acknowledgments. Advantage was taken of a contribution towards the expenses by the Research Grant Board to study the genus *Rhus* in European herbaria, and I would therefore like to acknowledge here also my indebtedness to this Board. My acknowledgments are also due to Mr. R. A. Dyer, M.Sc., who assisted me with dissections, etc., during the last few years, and to Miss G. Britten, who typed this paper.

(preserved at Oxford and representing a number of Linnaeus' types), British Museum (Sloane collection and some of the types of Aiton's Hortus Kewensis), Linnaeus, at the Linnean Society, London (mostly specimens culled by the younger Linnaeus from Thunberg's Herbarium), Lamarck (at the Jardin des Plantes, Paris), Thunberg (preserved at Upsala), and Willdenow (Berlin). I have also seen Jacquin's types (Vienna) and the types of *Dasystemon* DC. (Candollean Herbarium, Geneva). Some years ago Mr. J. G. Baker compared some of our material with Harvey's Herbarium (Dublin). Thunberg's Herbarium especially yielded a rich harvest,* as there are 45 species (out of 47 in his Flora Capensis, ed. Schultes) preserved in it, and evidently it had not been used by any writer on *Crassulae* for at least 100 years. The best set of Ecklon and Zeyher's collections which I have seen is in the South African Museum, Capetown, while the best set of Drège's collections is at Paris. Very few types only of Haworth's species are preserved. There are, however, some of his drawings at Kew.

For many years I have studied living specimens, in which I have been greatly helped by almost all South African botanists, yet I feel that even now the time is not ripe for a monograph of the genus. However, as the number of species has been more than doubled since Harvey's time, I thought it advisable to make an attempt at a connected presentation of the South African species, so that students at all events will know where to turn in order to get hold of the extremely scattered information. I have taken rather a broad view of the limits of the species, *e.g.* many botanists would have made 10–12 species of the forms which I have placed under *Cr. rubicunda.*

History of the Genus.—Although I have almost full data on this point, no good purpose would be served if I treated it in complete detail. Almost from the first, when South African Crassulas were introduced into European gardens or sent as dried specimens, they were described and some of them (usually badly) figured. Many of them were included in various publications of Linnaeus. Thunberg, who collected for some years in South Africa, described a number of new species in various publications (*e.g.* in Nova Acta Acad. Caes. Natur. Cur., vi, 1778), and a fairly comprehensive account of the species known to him will be found in his Flora Capensis, ed. Schultes (1823). A. H. Haworth cultivated a number of them, described them in various publications, and gave a comprehensive account in Synopsis Plantarum Succulentarum (1812, 1819) and Revisio Pl. Succ. He divided the species into a number of genera, reference to some of which will be made later. None of them have received recognition by modern botanists, and

* *Cr. adscendens* Thunb., *loc. cit.*, 330, 341 (*Cr. ascendens* Harv.) is not preserved, and has subsequently not been referred to by Thunberg. See S. Schonland, "The genera *Rhus* and *Crassula* in Thunberg's Herbarium at Upsala," Arkiv för Botanik, xxiA, No. 16, 1927.

some were already suppressed by Jussieu in the Dictionnaire des Sciences Naturelles, vol. xi.

Aug. Pyr. de Candolle in his Mémoire sur la famille des Crassulacées (1828) and in Prodromus, vol. iii (1828), keeps up 8 genera :

1. *Tillaea* Mich. " Petala 3–5. Squamae 0. Carpella 2-sperma." The number of floral parts cannot, however, be used as a generic character. The absence of squamae rests in some cases on an error of observation. The number of ovules again cannot be used as generic character (see Schonland in Ann. Bolus Herb., ii, 141). These remarks as regards numbers of petals and ovules apply also to the next genus.

2. *Bulliarda* L'Her. " Petala 4. Squamae lineares. Carpella ∞-sperma."

3. *Dasystemon* DC. (*Cr. calicina* Desf.). " Petala 3–7. Stam. filamenta crassissima ovata." This genus should be ignored. (See remarks under *Cr. scabra.*)

4. *Septas* L. " Petala 5–9. Stam. filamenta subulares." De Candolle himself points out (Mémoire, p. 16) that the number of floral parts (5–9, in *Cr. Septas* often 7) is in itself of no importance, but the vegetative organs (tuberous stem-structures) give the genus a distinctive character. This again has not been adopted by modern botanists.

5. *Crassula* L. " Petala 5 (raro 4) apice acuminata. Stam. filamenta subulata." Many species placed here have the petals not " acuminate," and their filaments are not subulate. He states (*loc. cit.*, p. 17) that the squamae are oval and very small, which character distinguishes the tetrandrous *Crassulae* from *Bulliarda* (which, however, does not hold good), and that the polyspermous carpels distinguish it from *Tillaea* (a very artificial distinction). De Candolle, partly following Haworth, distinguishes the following sections of *Crassula*: (1) Latifoliae, (2) Subulosae, (3) Squamulosae, (4) Columnares, (5) Perfilatae, (6) Petiolares, (7) Deltoideae, (8) Turgoseae, (9) Rosulares, (10) Glomeratae, (11) Tillaeoideae, most of which were adopted by Harvey in Harvey and Sonder, Fl. Cap., ii. In these sections far too much reliance is placed on vegetative characters.

6. *Globulea* Haw. " Petala 5, apice globulo terminata." When one considers extreme forms, this genus appears to be well characterised, but it is connected by intermediate forms, especially through species allied to *Cr. turrita* ; and, moreover, the mucro so often seen on the petals of other *Crassulae*, though not globular, is the morphological equivalent of the nearly globular appendage of the petals in *Globulea*. This appendage is often (*e.g.* by Harvey) erroneously described as glandular.

7. *Curtogyne* Haw. " Gamopetala. Petala 5 in corollam, 5-partitam basi concreta. Squamae breves. Styli longi sublaterales." Haworth (in Rev. Pl. Succ., p. 8) adds : " Ovaria apice gibbosa."

There are few Crassulas in which the petals are quite free, and they are even more gamopetalous in *Globulea*. The ovaries do, however, in some species, not pass gradually into the style but arise somewhat abruptly apically on the dorsal side of the ovaries. The ventral side at the apex is rounded and may project slightly, but can hardly ever be described as gibbous.

8. *Rochea* DC. p. pte. He includes in this genus *Cr. perfoliata* L. and *Cr. falcata*.

Ecklon and Zeyher in Enumeratio Plant. Afr. Austr. Extratrop. (1835–37) keep up all Candollean genera, also *Pyrgosea* Sweet (*Turgosea* Haw.), to which *Cr. turrita* and allied species are referred. They also established the following new genera, none of which have been kept up by later authors except *Helophytum* by Harvey :—

1. *Helophytum*. Flowers tetramerous. Carpels 4-spermous. (The last statement is incorrect and has been put right by Harvey. They are 1-spermous.)

2. *Sarcolipes*. This genus is only distinguished from *Bulliarda* by having pentamerous flowers, and if the latter has to fall there is much more reason to sink *Sarcolipes* in *Crassula*.

3. *Petrogeton*. Here again there is no satisfactory floral character to distinguish this genus from *Crassula*, and the vegetative characters have to be ignored if *Septas* is sunk in *Crassula*, as was done already by Thunberg.

4. *Tetraphyle*. This is a mixed lot, throwing together such plants as *Cr. pyramidalis* and *Cr. ericoides*. Their *Tetraphyle corallina* is not a crassulaceous plant. It is *Anacampseros ustulata*.

5. *Sphaeritis*. Typical forms with their folded petals are very distinct, but there are intermediate forms which connect it with typical *Crassula*. The very short, thickened style is also found in *Globulea* and some otherwise typical *Crassulae*.

6. *Thisantha*. Contains some species with pentamerous flowers which I have placed under the sect. *Tillaeoideae*. The statement by the authors that the squamae are absent is incorrect. They are found in all South African species.

Harvey, in the 2nd vol. of Harvey and Sonder's Flora Capensis, keeps up the genera *Helophytum*, *Bulliarda*, and *Crassula* (besides *Grammanthes* DC. and *Rochea* DC. amongst haplostemonous Crassulaceae, with which we are not concerned here, although earlier authors included them in *Crassula*). How artificial *Bulliarda* is may be gathered from the fact that in all types of *Bulliarda Dregei* Harv. which I have seen there are pentamerous flowers in addition to tetramerous ones.

He also founded the genus *Dinacria*, which, according to him, is distinguished from *Crassula* chiefly by a hornlike crest at the back of each style.

Bentham and Hooker in the " Genera plantarum " kept up the following genera :—

1. *Tillaea.* " Flores 4–5-meri. Calyx corollae brevior vel aequans. Herbae annuae, parvulae, foliis oppositis." This genus, established by Linnaeus, had already been rejected by Thunberg (see his Fl. Cap., ed. Schultes, p. 279).

2. *Dinacria.* " Flores 5-meri. Petala unguiculata. Carpella apice pone stigma cornuta. Herba pusilla, foliis oppositis."

3. *Crassula.* " Flores 5-meri. Calyx corollae brevior. Suffrutices saepe crassae vel carnosae."

In Engler and Prantl's Natürliche Pflanzenfamilien I united these genera after consultation with the late Sir Joseph Hooker, but for a number of years now I have been of opinion that *Dinacria* (of which 3 species are known now) should be restored. The dorsal crest (or rather knob) on the styles is the real stigma and forms a curious parallel to the dorsal mucro of the petals of so many *Crassulae.*

There is a decided tendency in some *Crassulae* (especially in sect. *Globulea*) to have subdorsal stigmata, but they are never removed from the apparent apex of the styles. *Dinacria* is, therefore, not included in the following pages under *Crassula.*

Relation of the Genus Crassula to other Crassulaceous Genera.

In the scheme which I gave in Engler and Prantl, Natürliche Pflanzenfamilien, I assumed that *Crassula* is derived from the generally ob-diplostemonous genus *Sedum.* This genus has a section *Pro-crassula* in the Mediterranean region (incl. the Canary Islands) and in Central Europe with generally haplostemonous flowers. The species resemble the annual species of *Crassula*, from which they can be distinguished by their alternate leaves. One species is often tetramerous. Whether they really form a connecting link between the two genera cannot be definitely decided. In any case no fact is known to me that would change my view of favouring the derivation of *Crassula* from *Sedum.* Other diplostemonous genera need hardly be considered.

Amongst haplostemonous genera *Rochea* and *Grammanthes*, both restricted to S.W. Cape Province, are evidently derived from *Crassula*, and this conclusion applies to *Dinacria* (S.W. Cape Province to the neighbourhood of Grahamstown) and *Pagella* Schonl., a very aberrant genus with syncarpous ovary known only from Montagu and Matjesfontein. In connection with the latter I may mention that while *Crassula* is usually described as apocarpous, there are a large number of species in which the carpels are slightly united at the base, but there is no real transition known between

the two genera, just as we have no decided transition to *Dinacria*, *Rochea*, and *Grammanthes*, though their essential characters are, as it were, started in many species of *Crassula*.

Main Principles in classifying the Species of Crassula.

In trying to get a phylogenetic classification we must attempt to get a starting-point in order to distinguish between primitive and derived characters. I have on a previous occasion indicated that I look upon the annual species as the most primitive ones from which the others have been developed. These are all included in my sect. *Tillaeoideae* (Ann. Bolus Herb., ii, 41). For this view the geographical distribution forms a very strong argument. In this section the *Muscosa* group is of almost world-wide distribution. *Cr. Vaillantii* is also very widely distributed. *Cr. natans* is found in South Africa, East Africa, and Australia. Species which are close to *Cr. umbellata* Thunb. are found in South America, etc. Nothing compared to this wide distribution, which especially in Australia and South America is accompanied by the differentiation of a number of species,* is found in any other section of *Crassula*. Only a couple of groups of my sect. *Campanulatae* extend beyond South Africa to Tropical Africa and with very few species to Asia, and a few species of the sect. *Stellatae* are found in Tropical Africa. Of course we know that moisture-loving plants, such as many *Tillaeoideae*, with small seeds tend to have a wide distribution, but there are quite a number of other moisture-loving *Crassulae* which are restricted to South Africa.

If the sect. *Tillaeoideae* is looked upon as the most ancient section, we need not be surprised to find that it shows great diversity and that some groups, as is actually the case, lead up to several other sections or groups of such sections.

If my views are correct, then we have in the genus *Crassula* a transition from hydrophilous species to extreme xerophytic species, a course which has evidently been followed by many other orders and genera in South Africa, though few may have started from quite such an opposite extreme. In the genus *Crassula* we can on this hypothesis, at all events, construct a fairly consistent, though not unbroken, series of the species now living. Of course a single linear series could never represent the relationships; a scheme prepared on these views will be found on p. 159.

Though some species of sect. *Tillaeoideae* could be placed at the beginning of various other sections, even then the remainder would represent a

* Ostenfeld (in Dansk Botanisk Arkiv, Bind ii) enumerates 8 species of *Crassula* sect. *Tillaeoideae* from West Australia, some of which belong to the following groups: *Helophytum*, *Vaillantii*, *Umbellata*.

rather heterogeneous assemblage in their floral structure. The large majority have stellate flowers. Only in one or two is there a slight indication of a mucro on the petals. In the *Stellatae* we have still stellate flowers, generally without an indication of a mucro on the petals, but the structure of the flowers has become remarkably uniform. In the *Tuberosae* we find usually stellate flowers, but there are some species in which the petals are more or less erect, all still without a mucro. In the remaining sections the flowers have erect or erecto-patent petals, which are flattish or boat-shaped in the sect. *Campanulatae* (forming a campanulate or urceolate corolla); conduplicate at the apex or narrowed into a thickened point at the apex, in sect. *Sphaeritis*; panduriform in their free portions in sect. *Globulea*; contracted at the apex into strap-shaped structures in *Pyramidella*. In the *Campanulatae* there is, as a rule, a small mucro behind the apex of the petals; in *Sphaeritis* a mucro is rare; in *Globulea* it is very conspicuous, egg-shaped or globular; and it is absent in *Pyramidella*. In the *Campanulatae* we can trace a gradual diminution in the relative length of the style and an increase in the size of the squamae, characters which become more pronounced in the remaining sections. Judging from these characters, the *Stellatae, Tuberosae, Campanulatae,* and *Pyramidella* have their roots directly in the *Tillaeoideae*.

The sect. *Stellatae, Tuberosae,* and *Pyramidella* seem to be monophyletic, while this can hardly be the case with *Campanulatae*. From the latter must have developed the sect. *Sphaeritis* and *Globulea*, but again *Sphaeritis* is not likely to be monophyletic.

As regards the inflorescences one can only make the vague statement that on the whole all sections, except the *Tillaeoideae*, have more or less complicated inflorescences with cymose branching. In *Stellatae* and *Tuberosae* they are comparatively simple (in both even single flowers are exceptionally found).

Already in the *Tillaeoideae* we find, in addition to hydrophytic and hydrophilous, annual species, also a number of perennials, often distinctly xerophytic, whereas all other sections are composed of perennial species (monocarpic in *Pyramidella*), but sect. *Tuberosae* is composed only of hydrophilous species. Such are also found in the *Stellatae*, and even in some *Campanulatae*. Even some succulent species, e.g. *Cr. Galpini*, are restricted to damp places.

A notable feature is the parallelism exhibited in vegetative characters of plants belonging to different sections (compare e.g. *Cr. corallina* [sect. *Tillaeoideae*], the Arta group [sect. *Campanulatae*], and sect. *Pyramidella*). Vegetative characters can, therefore, on the whole, only be used as secondary aids in the broad arrangement of the species of *Crassula*, but are often very useful in establishing groups. A detailed and comparative account of the

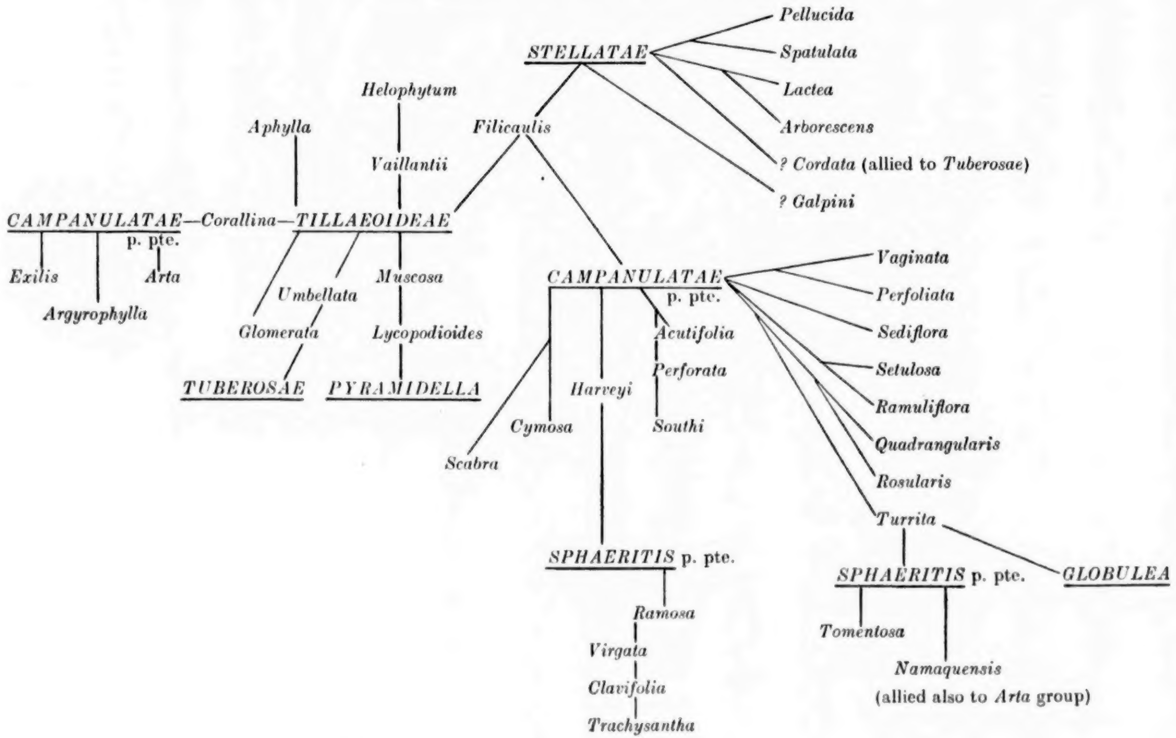
vegetative organs of the genus is beyond the scope of this paper. Such an account would also have to deal with vegetative reproduction and other ecological features, many of which I have in a disconnected form already referred to in previous papers [compare Journ. Linn. Soc. (Bot.), xxxi; Bull. de l'herb. Boissier, v (1897); Journ. of Bot., 1898, 1902; Engl. Bot. Jahrb., xliii (1909), xlv (1910); Rec. Albany Mus., vols. i, ii, iii; Ann. S.A. Mus. ix (1912); Ann. Bolus Herb., ii (1916, 1917)], while others can be gleaned from the descriptions of the sections, groups, and new species in the present paper. I may perhaps mention that while in the vegetative organs a transition to xerophytic types will be quite apparent, I look even upon the transition of the flowers from a stellate to campanulate or urceolate structure as a xerophytic adaptation, *e.g.* in the *Stellatae* we find such extreme Xerophytes as *Cr. arborescens* and *Cr. argentea* flowering only in the cool months, namely, in winter or spring; while other species with stellate flowers are moisture-loving, or at all events, if they flower in summer, are absent from the arid parts of South Africa. In the sect. *Globulea* they are permanently closed and only certain insects can gain access to them (*cf.* Schonland in Trans. S.A. Phil. Soc., ix, t. 1).

Fruits and seeds, unfortunately, do not afford taxonomic characters of any value. The follicles retain the form of the carpels before the seeds are formed, only the ovaries swelling up slightly.

CRASSULA L. (emend. Schonl.) SYNONYMS (mostly ex Ind. Kew.).

Crassula Dill. ex Linn. Syst., ed. 1 (1735).
Bulliarda DC. in Bull. Soc. Philom., iii (1801), No. 49, 1.
Combesia A. Rich., Tent. Fl. Abyss., 1, 307 (1847).
Crassularia Hochst. ex Schweinf. Beitr. Fl. Aethiop., 80 (1867), *partim.*
Curtogyne Haw., Rev. Pl. Succ., 8 (1821).
Dasystemon DC., Mémoire sur la famille des Crassulacées (1828).
Disporocarpa A. Rich., *loc. cit.*, 307, in Syn. (1847).
Globulea Haw., Syn. Pl. Succ., 60 (1821).
Gomara Adans., Fam., ii, 248 (1763).
Helophytum E. &. Z., Enum., 288 (1836).
Kalosanthes Haw., Rev. Pl. Succ., 6 (1821), *partim.*
Larochea Pers., Syn., 1, 357 (1805).
Mesanchum Dulac, Fl. Hautes-Pyr., 320 (1867).
Petrogeton E. & Z., Enum., 291 (1837).
Purgosea Haw. in Phil. Mag., iii, 124 (1828).
Pyrgosea Sweet, E. & Z., Enum., 298 (1837), =*Purgosea.*
Rochea DC., Prodr., 3, 393 (1828), *partim.*
Sarcolipes E. & Z., Enum., 299 (1837).

SCHEME TO INDICATE THE PHYLOGENETIC RELATIONSHIPS OF THE SECTIONS AND GROUPS OF THE GENUS *CRASSULA* L. (EMEND. SCHONL.).



Septas Linn., Pl. Afr. Rar., 10 (1760); Amoen. Acad., 7, 87 (1764).
Sphaeritis E. & Z., Enum., 299 (1837).
Tetraphyle E. & Z., *loc. cit.*, 292 (1837).
Thisantha E. & Z., *loc. cit.*, 302 (1837).
Tillaea Mich. ex Linn. Syst., ed. 1 (1735).
Tillaeastrum Britton in Bull. New York Bot. Garden, iii (1903), 1.
Turgosea Haw., Rev. Pl. Succ., 14 (1821).

CRASSULA L. (*amended description*).

Annual or perennial herbs, rarely tuberous, frequently with fleshy stem and leaves or half-shrubs often with woody stem, rarely fleshy shrubs. Leaves (very rarely absent), decussate or collected in a rosette, the pairs often more or less connate at the base, usually sessile, almost always entire, flattish, semiterete or subterete, on the surfaces glabrous, pubescent, papillose or scabrid, on the margin smooth, ciliate or papillate. Flowers rarely solitary, usually in multiflowered corymbose, subumbellate, capitate or thyrsoid inflorescences, isomerous, haplostemonous, 5–4–3 (rarely 6–9) merous. Calyx usually much shorter than the corolla, usually suberect, slightly gamosepalous, lobes often lanceolate or subovate. Petals rarely free, usually slightly connate at the base, white or red, rarely yellow, or more rarely bluish, lobes very diversified: stellate, erect, erecto-patent or connivent, lanceolate ovate, obovate oblong or panduriform, sometimes folded in the upper part, etc., behind the apex very often dorsally mucronate, the mucro small, hemispherical or cylindrical, usually blunt or conspicuous, ovoid or subglobular. Stamens (in the subgamopetalous corollas affixed to the tube) shorter than the lobes, filaments often subulate, sometimes flattened, anthers ovate or oblong, sometimes with conspicuous connective. Carpels free or slightly united at the base; ovaries multi-ovuled, rarely with few or even 1 ovule, at the apex usually gradually attenuate; styles often subulate, narrowly cylindrical or filamentous, often as long as the ovaries, or short and then often relatively thick; stigmata small, terminal or more rarely subdorsal. Nectar-scales (" squamae ") present in all South African species, usually very small but sometimes up to one-half the length of the ovaries, usually obcuneate, rounded and slightly emarginate at the apex, rarely stipitate. Fruit an aeterio of follicles.

SHORT DESCRIPTIONS OF SECTIONS AND GROUPS.

Keys to the Species.

SECT. I. TILLAEOIDEAE Schonl. in Ann. Bolus Herb., ii, 42 (includes the following in Harvey and Sonder, Fl. Cap., ii: *Helophytum* E. et Z.,

Bulliarda DC., *Cr.* sect. *Lycopodioides*, sect. *Glomeratae*, sect. *Filipedes* p. pte.).

Small, mostly annual plants adapted in the majority of species to damp conditions (some are real water plants), while a few are distinct Xerophytes. Flowers, found singly or in simple inflorescences, leading up to various other sections in their structure. Petals almost invariably without a mucro, usually stellate. Squamae (nectar-scales) present as in all other South African species of *Crassula*.

Represented in all parts of South Africa, the majority of species in S.W. Cape Province.

Helophytum group. Annuals. Water plants. Stem simple or slightly branched, lower internodes elongated, upper often shortened. Flowers solitary, axillary or in axillary cymules, pedicellate, 4-merous. Carpels 1-ovulate.

Widely spread in the coast regions of South Africa and the Transvaal, one species also in East Africa and Australia.

A. Stem slender, filiform. Flowers usually axillary. Calyx lobes very short, 1. *Cr. natans* Thunb.
B. Stem slightly swollen, hollow. Flowers in subsessile axillary cymules. Calyx lobes much longer than in 1 . . . . . . 2. *Cr. inanis* Thunb.

Vaillantii group. Annuals. Marsh or land plants. Stem simple or forked. Flowers axillary or terminal, 4-merous. Carpels usually with 6–8 ovules, sometimes more, rarely less (in the same species).

Four species South-Western, one with rather erratic distribution, extending to many other parts of the world, one on high mountains in Cape Province.

A. Leaves and sepals papillose . . . 3. *Cr. papillosa* Schonl. et Bak. f.
B. Leaves and sepals glabrous.
  a. Leaves longer than flowers.
    1. Calyx-lobes ovate, obtuse . . . 4. *Cr. Vaillantii* (Willd.) Roth.
    2. Calyx-lobes lanceolate, acute, ovaries multi-ovulate, 5. *Cr. decumbens* Thunb. (non E. et Z.).
    3. Calyx-lobes obovate obtuse, ovaries multi-ovulate, 6. *Cr. Roggeveldii* Schonl.
    4. Calyx-lobes oblong, acute, ciliate on the margin, ovaries 1–4 ovulate, 8. *Cr. langebergensis* Schonl.
  b. Leaves shorter than flower . . . 7. *Cr. brevifolia* (E. et Z.) Schonl.

Aphylla group. Small annual with sparingly branched stem. Leaves often absent and then internodes swollen (somewhat like the joints of an *Opuntia*). Flowers terminal, normally 4-merous. Carpels 2–4 ovulate. Western Region.

9. *Cr. aphylla* Schonl. et Bak. f.

Filicaulis group. Annuals with elongated, rarely with shortened, inter-

nodes. Flowers solitary on filiform pedicels, usually in the axils of the upper leaves, sometimes terminal, normally 5-merous. Carpels pluri-ovulate.

One species fairly generally distributed in South Africa, four South-Western, one (also in Tropical Africa) in the Transvaal.

A. Pedicels elongating after flowering.
  a. Quite glabrous . . . . 10. *Cr. expansa* Dryand.
  b. More or less pubescent . . . . . 11. *Cr. browniana* Burtt-Davy.
B. Pedicels not elongating after flowering.
  a. Internodes short . . . . 15. *Cr. uniflora* Schonl.
  b. Internodes elongated.
    1. Calyx much longer than corolla . 14. *Cr. Lambertiana* Schonl. et Bak. f.
    2. Calyx and corolla about equal in length or calyx somewhat shorter.
      * Leaves elliptical or oblanceolate, very obtuse, pedicels 1·2–2·4 cm. long, 12. *Cr. tenuis* Wolley Dod.
      ** Leaves oblanceolate or oblong-obovate, somewhat obtuse, pedicels short, 13. *Cr. oblanceolata* Schonl. et Bak. f.

Glomerata group. Annuals with usually richly branched stem and with axillary or terminal inflorescences. Flowers normally 5-merous. Carpels with 2 (rarely 1) ovules.

Restricted to S.W. and W. Cape Province.

A. Flowers mostly in glomerate or sometimes cymoso-paniculate terminal inflorescences . . . . 16. *Cr. glomerata* L.
B. Flowers in few-flowered axillary and terminal short inflorescences.
  a. Calyx lobes longer than corolla.
    1. Leaves linear. Calyx-lobes linear, acute. Petals oblong, blunt. Ovaries 2-ovuled . . . . 17. *Cr. Zeyheriana* Schonl.
    2. Leaves ovate. Calyx-lobes ovate, obtuse. Petals lanceolate. Ovaries 1-ovuled . . . . 18. *Cr. parvipetala* Schonl.
  b. Calyx-lobes shorter than corolla. Stem prostrate, white, angular, 19. *Cr. albicaulis* Harv.
C. Flowers in more or less lax inflorescences.
  a. Stem and leaves hairy. Leaves lanceolate, 20. *Cr. hirsuta* Schonl. et Bak. f.
  b. Stem and leaves glabrous. Leaves oblong, ovate or spathulate.
    1. Pedicels short . . . . . 21. *Cr. minutiflora* Schonl. et Bak. f.
    2. Pedicels slender . . . 22. *Cr. tenuipedicellata* Schonl. et Bak. f.

Muscosa group. Small annuals or perennials with mosslike aspect, frequently with numerous short axillary branches, often with imbricate leaves. Some species favour damp situations, others are distinctly xerophytic. Flowers subsessile or shortly pedicelled, very small, either solitary or in small tufts. Petals almost free. Ovaries in Nos. 26, 27 multi-ovulate, in the others 2-ovulate.

Some species generally distributed in South Africa, others either in the East or South-West. Also in Tropical Africa, Europe, Asia, N. and S. America, Australia.

A. Herbaceous annuals or perennials.
  a. Petals ovate, subacute, minutely cuspidate. Leaves ovate or sublanceolate, obtuse or acute. Internodes fairly regular, as long or longer than the leaves, 23. *Cr. filamentosa* Schonl.
  b. Petals lanceolate acuminate or hair-pointed. Leaves much acuminate or hair-pointed. Internodes usually very short . 24. *Cr. campestris* (E. et L.) Harv.
  c. Petals blunt, rounded at the apex. Leaves with rough margin.
    1. Sepals slightly longer than the petals . . 27. *Cr. bergioides* Harv.
    2. Sepals nearly three times the length of the petals, 28. *Cr. aristata* Schonl.
B. Perennials. Stem woody (often tuberous in No. 25) at the base.
  a. Leaves ovate-lanceolate, tapering to a blunt point. Branches slightly flexuous. Calyx shorter than petals . . . . . . 25. *Cr. parvula* Endl.
  b. Leaves from an oval base lanceolate acute. Branches usually straight. Calyx about the length of the petals . . . 26. *Cr. transvaaliensis* O. K.

Lycopodioides group. Small xerophytic half-shrubs with closely set 4-ranked leaves, with elongated branches, and often also with numerous short axillary branchlets. Flowers 5-merous, subsessile, very small, either solitary or in few-flowered dense cymules in the axils of the upper leaves. Carpels with more than 2 ovules. Namaqualand to Naauwpoort, in the coast districts to Komgha.

29. *Cr. lycopodioides* Lam.

Umbellata group. Marsh or land plants with somewhat fleshy spathulate, sessile or distinctly petiolate, flattish or ovoid-subtrigonous or elliptic-subtrigonous; subrosulate or scattered leaves. Inflorescence sub-umbellate with long-pedicelled flowers or capitate, 4-merous or 5-merous. Carpels with more than 2 ovules.

In South Africa restricted to south-western region, one extending to Port Elizabeth ; also in Australia and South America.

A. Flowers usually 4-merous.
  a. Stem slender, richly branched . . . 30. *Cr. Dodii* Schonl. et Bak. f.
  b. Stem simple or sparingly branched.
    1. Petals ovate, obtuse . . . . . . 31. *Cr. umbellata* Thunb.
    2. Petals ovate-lanceolate, acuminate . . . 32. *Cr. Marlothii* Schonl.
B. Flowers 5-merous.
  Stem and leaves pubescent . . . . . . 33. *Cr. silvatica* Licht.

Corallina group. Small herbaceous perennials with many short decumbent, densely leafy branches rooting readily at the lower nodes. Flowers 5-merous, from the axils of the upper leaves, usually pedicelled. One species in arid parts from the S.W. Protectorate to the Eastern Karroo, one on the Witbergen.

A. Leaves connate, oblong, obtuse . . . . 34. *Cr. peploides* Harv.
B. Leaves compressed-subglobose or ellipsoidal . . 35. *Cr. corallina* Thunb.

SECT. II. STELLATAE Schonl.

Fleshy thick-stemmed succulent shrubs or perennial herbs with slender stems and laxly leafy branches. Leaves sessile or petiolate with flattish blades, ovate or cordate-ovate, rarely subsemiterete, margin smooth or crenate or rarely serrulate. Inflorescence usually terminal, thyrsoid or subumbellate. Petals lanceolate, spreading from the base, without mucro or rarely mucro faintly indicated. Filaments subulate, anthers oblong. Ovaries elongated. Styles subulate. Squamae minute, obcuneate.

Distributed most largely in the south-eastern coast region of South Africa, slightly extending westwards and into Tropical Africa.

Pellucida group. Herbaceous, diffuse, weak-stemmed perennials, with elongated internodes, with glabrous or rarely pubescent flattish entire succulent leaves. Flowers on slender pedicels, solitary, axillary or more frequently congregated in terminal subumbellate inflorescences.

Found in dampish places and rock-crevices chiefly in the coast districts, extending inland especially towards the east in the mountains, also in the Transvaal.

A. Flowers mainly or entirely in terminal inflorescences.
  1. Inflorescence subcapitate, involucrate . . . 42. *Cr. involucrata* Schonl.
  2. Apical inflorescence usually subumbellate.
    * Petals 2 mm. long, ovate. Sepals about 1 mm. long. Plant glabrous, 40. *Cr. Woodii* Schonl.
    ** Stem coarsely hirsute, leaves sparsely hirsute or subglabrous, 41. *Cr. Tysoni* Schonl.
    *** Stem and leaves glabrous or more rarely pubescent. Petals over 2·5 mm. long.
      1. Leaves sessile or attenuate at the base into a more or less distinct petiole, pilose at the base, frequently copiously lineolate. Petals not exceeding 5·5 mm. in length . . . . . 38. *Cr. lineolata* Dryand.
      2. Leaves sessile, quite glabrous, usually with a row of spots along the margin. Petals not exceeding 5·5 mm. in length, 37. *Cr. marginalis* Dryand.
      3. Leaves sessile or subsessile, quite glabrous, without spots. Petals 6·5–8 mm. long, rarely somewhat shorter . . 36. *Cr. pellucida* L.

B. Flowers solitary on long delicate pedicels. Leaves oblong or ovate-cuneate, often attenuate into a petiole, blade 4–6 mm. long . 39. *Cr. tenuicaulis* Schonl.

Spatulata group (*Petiolares* p. pte. in Fl. Cap., ii, 334). Perennial, procumbent or erect, rarely scrambling, weak-stemmed herbs with long internodes and flattish, petioled succulent leaves. Flowers in loose terminal cymose-corymbose inflorescences. Very close to the preceding group.

Usually in dampish, shady localities and in crevices of rocks, occurring from Humansdorp to Natal.

A. Leaf-blades broadly cordate, margin crenate . . 43. *Cr. spatulata* Thunb.
B. Leaf-blades suborbiculate or broadly ovate, rounded at the base, margin minutely crenato-serrate . . . . . . 44. *Cr. cyclophylla* Schonl. et Bak. f.
C. Leaf-blades ovate, acute, margin rather coarsely crenato-serrate, 48. *Cr. sarmentosa* Harv.
D. Leaf-blades ovate or elliptical, attenuated at the base, minutely squamulose, margin denticulate or subdenticulate . 47. *Cr. inandensis* Schonl. et Bak. f.
E. Leaf-blades ovate or orbiculate, attenuate at the base, margin crenate or crenate-serrate . . . . 45. *Cr. latispatulata* Schonl. et Bak. f.
F. Leaf-blades ovate, cuneate at the base, acute at the apex, margin sinuate or crenate, the crenations glauco-pulverulent . . . 46. *Cr. Wyliei* Schonl.

Lactea group. Succulent shrubs branched from the base with broad flattish leaves. Flowers in terminal cymose-corymbose or thyrsoid inflorescences.

Found in shady places or rock-crevices from Knysna div. to Natal and the Transvaal, 1 species in Namaqualand.

A. Quite glabrous. Leaves connate.
  a. Leaves obovate, narrowed at the base, subacute or acuminate, 49. *Cr. lactea* Soland.
  b. Leaves obliquely ovate, obtuse, greyish . . 50. *Cr. Sladeni* Schonl.
  c. Leaves obovate, obtuse, narrowed at the base into the petiole, multipunctate, 51. *Cr. multicava* Lem.
B. Stem minutely scaberulous. Leaves distinct . 52. *Cr. lignosa* Burtt-Davy.

Arborescens group. Large, much-branched glabrous shrubs, often sub-arborescent, reaching a height of 10–12 feet. Stem, branches, and leaves very fleshy. Leaves flattish. Flowers white or rosy in cymose-paniculate inflorescences.

Dry karroid slopes from Namaqualand to Natal, in some places very common (*e.g.* in the Fish River bush *Cr. argentea* dominates the landscape when in flower).

A. Leaves covered with a greyish waxy bloom, roundish-obovate, obtuse, copiously and distinctly punctate . . . . . 53. *Cr. arborescens* Willd.
B. Leaves green, shining, ovate or obovate, acute or subacute, generally smaller than in the preceding species . . . . . . 54. *Cr. argentea* Thunb.

Cordata group. Succulent shrublets, generally not reaching 1 foot in height, with glaucous, soft, petioled leaves and weak stems. Flowers in cymose paniculate inflorescences. Generally growing in rock-crevices or stony slopes amongst karroid scrub, from the neighbourhood of Uitenhage to Natal.

A. Leaf-blades ovate-cordate at base . . . . 55. *Cr. cordata* Thunb.
B. Leaf-blades oblong suborbiculate cuneate or subcuneate at the base, 56. *Cr. glauca* Schonl.

Galpini group. A single species of rather doubtful affinities, though with substellate corolla. A very fleshy perennial glabrous herb, branched from near the base. Leaves crowded (except on the peduncle), semiterete, entire or rarely flattened and serrate at the apex. Inflorescence pedunculate, paniculate. Sepals fleshy, ovate, obtuse, much shorter than the petals, which are oblong obtuse, with recurved margin in the upper half. Carpels much shorter than the petals, with a very short filamentous style and very small stigma. Stamens developing in succession, when ripe reaching nearly the length of the petals.

On the highest mountains of eastern Cape Province from the Hogsback and Katberg to the Drakensberg Mountains.

57. ***Cr. Galpini*** **Schonl.**

Sect. III. Tuberosae Schonl. in Ann. Bolus Herb., ii, 87 (*Septas* L. in Pl. Afr. Rar., 10, 1770; *Petrogeton* E. et Z. p. pte. in Enum., 292 (1837); *Cr. Crenato-lobatae* and *Tuberosae* Harv. in Fl. Cap., ii, 335).

Fleshy perennials with tuberous, rarely elongated rhizome, sometimes also forming tubers in the floral regions. Leaves soft, flattish, entire, crenate or rarely deeply cut, sessile or petiolate, the pairs often approximate. Flowers 5-merous (sometimes 6–9-merous). Petals stellate or ascending, without mucro. Anthers usually with distinct connective. Styles filiform. Squamae minute.

(Compare relations to the following species in previous sections: *Cr. parvipetala*, *Cr. Marlothii*, *Cr. cordata*, and *Cr. glauca*.)

Some of the species have a wide range of variations. I suspect that some of these are brought about by hybridisation.

Usually in damp shady localities, especially in rock-crevices, chiefly in S.W. Cape Province, but extending to Natal.

A. Inflorescence paniculate or cymose-corymbose, terminal or lateral.
- *a.* Leaves more than 2.
  - α. Leaves thin, usually with long petiole, blades broad, sinuate or repando-crenate on the margin . . . . . 58. *Cr. dentata* Thunb.
  - β. Leaves attenuated at the base into a short petiole, blades broad with entire or obscurely crenate margin.
    1. Calyx-lobes obtuse, 1/3 the length of the corolla, 61. *Cr. confusa* Schonl. et Bak. f.
    2. Calyx-lobes subacute, 2/3 the length of the corolla, 60. *Cr. nemorosa* Endl.
  - γ. Leaf-blades oval or transversely reniform, contracted at the base, only 2–3 mm. long . . . . . . 66. *Cr. coerulescens* Schonl.
  - δ. Leaf-blades narrowly obovate or oblong, serrate-crenate on the margin, 1·5–3 cm. long . . . . . . 65. *Cr. simulans* Schonl.
- *b.* Leaves 2, sessile (or perfoliate-disciform) or cuneate at the base.
  - α. Leaves 1·4–1·8 cm. long . . . . . 73. *Cr. Weissii* N. E. Br.
  - β. Leaves 2–7 cm. long . . . . . . 72. *Cr. Umbella* Jacq.

B. Inflorescence terminal, subumbellate, usually few-flowered, rarely reduced to 1 flower.
  a. Petals ovate-lanceolate, acute, stellate or substellate.
    α. Leaf-blades crenate or crenate-dentate . 64. *Cr. umbraticola* N. E. Br.
    β. Leaf-blades cut to the base, main lobes again irregularly cut. 71. *Cr. alcicornis* Schonl.
  b. Petals subovate, obtuse or acuminate, stellate or substellate.
    α. Leaf-pairs 2, leaves petiolate, blade reniform up to 9 mm. broad, 59. *Cr. Dielsii* Schonl.
    β. Leaf-pairs usually 4.
      * Leaves subsessile, not much exceeding 5 mm. in length, 70. *Cr. Albertiniae* Schonl.
      ** Leaves spathulate, subpetiolate, c. 2 cm. long, 69. *Cr. Bartlettii* Schonl.
      *** Leaf-blades 1 cm. or more long, broader than long, rarely suborbicular or ovate, attenuate at the base into a petiole, repando-crenate on the margin.
        0. Petals not exceeding 5 mm. in length.
          † Pedicels c. 2 mm. long, calyx-lobes ovate obtuse, 63. *Cr. loriformis* Schonl. et Bak. f.
          †† Pedicels usually more than 5 mm. long, calyx-lobes lanceolate-acute . . . . 62. *Cr. Promonterii* Schonl. et Bak. f.
        00. Petals 6–8 mm. long . . . . 67. *Cr. Septas* Thunb.
  c. Petals ovate-lanceolate acute, distinctly erecto-patent. Leaves usually 2, very broad, obtuse, crenate or bicrenate . . 68. *Cr. Saxifraga* Harv.

SECT. IV. CAMPANULATAE. Half-shrubs with fleshy or woody stem and more or less fleshy leaves or perennial herbs. Inflorescences various, frequently corymbose, often paniculate. Petals erect, more or less oblong, rarely connivent at the apex, usually more or less patent in the upper part, not conduplicate, usually with a distinct subapical small mucro. Styles mostly subulate, but reduced in some groups, squamae usually small. Into this section I place Harvey's *Eu-crassula, Glaucinae, Perfilatae, Subulares, Marginales, Thyrsoideae, Rosulares, Imbricatae*, but I cannot accept this subdivision, though some of my groups more or less coincide with some of Harvey's.

The plants belonging to this section are all distinct Xerophytes, many of them even extreme ones. The section is spread all over South Africa, and extends in one or two groups to Tropical Africa and even to the Himalayas and China.

Acutifolia group (*Subulares* Harv. in Fl. Cap. p. pte.). Glabrous, sparingly branched subshrubs with more or less woody stem (though in *Cr. acutifolia* often flowering while the stem is distinctly herbaceous). Stem and branches leafy, leaves often subimbricate, generally subterete, always acute. Flowers small, petals not exceeding 3 mm. in length. Inflorescences terminal, cymose-corymbose.

Widely spread in the coast districts of South Africa and extending to the dry interior portions, but not to the Kalahari region.

A. Leaves subterete-subulate, not exceeding 1·5 cm. in length.
  a. Petals erect or erecto-patent, not mucronate. Leaves green.
    α. Inflorescences pedunculate. Branches without small branchlets. Squamae about as broad as long.
      1. Petals 2–2·5 mm. long . . . . 74. *Cr. acutifolia* Lam.
      2. Petals 1·5 mm. long . . . . 76. *Cr. rudis* Schonl.
    β. Inflorescences sessile. Branches with numerous small branchlets. Squamae much broader than long . . . 75. *Cr. griquaensis* Schonl.
  b. Petals slightly connivent, mucronate. Leaves greyish, 78. *Cr. connivens* Schonl.
B. Leaves subtetragonous, 2–2·3 cm. long . . . . 77. *Cr. tetragona* L.
C. Leaves almost flat, lanceolate, acute, c. 2·2 cm. long . 79. *Cr. planifolia* Schonl.

Perforata group (*Perfilatae* Harv. and *Subulares* Harv. in Fl. Cap. p. pte.). Glabrous xerophytic sparingly branched subshrubs with woody or fleshy stem. Stem and branches leafy. Leaves distinctly connate or even perfoliate, fleshy, ovate, rhomboid, rarely oval or even lanceolate in outline. Leaf-margin smooth or cartilaginous-ciliate or rarely papillose-ciliate. Flowers small, petals not exceeding 3 mm. in length. Inflorescence terminal, thyrsoid or cymose-corymbose.

Mostly in Namaqualand and the Karroo. One species widely spread in dry rocky places in the coast districts of South Africa to Natal.

A. Stem and branches woody.
  a. Inflorescence thyrsoid. Leaves connate-perfoliate, ovate, acute or acuminate, cartilaginous-ciliate on the margin, especially in the lower part, 80. *Cr. perforata* Thunb.
  b. Inflorescence cymose-corymbose. Leaves connate-perfoliate, broadly ovate, acuminate, leaf-margin densely papillose-ciliate . 82. *Cr. conjuncta* N. E. Br.
  c. Inflorescence cymose-corymbose. Leaf-margin smooth.
    1. Leaves moderately thick, connate-perfoliate, subovate, subacute, 81. *Cr. rupestris* Thunb.
    2. Leaves subterete or semiterete, connate.
      * Leaves blunt, ovate, oval or rarely oblanceolate, not exceeding 1·2 cm. in length . . . . 84. *Cr. Pearsoni* Schonl.
      ** Leaves subacute or acute, subulate or oblong-lanceolate, 2–4 cm. long, 85. *Cr. MacOwaniana* Schonl. et Bak. f.
B. Stem and branches fleshy. Leaves connate, greyish pulverulent, subrhomboid subacute, contracted at the base, bluntly carinate on the back, broadly and deeply channelled above . . . . . . 83. *Cr. deltoidea* Thunb.

Harveyi group. Laxly branched xerophytic subshrubs with woody or fleshy stems and leafy branches. Leaves sessile, connate, glabrous or sparsely pubescent, ovate or lanceolate, usually more or less flattened, subacute or acute, usually considerably under 1·5 cm. in length and rarely exceeding this length. Inflorescence terminal, cymose-corymbose, pedunculate or sessile.

Petals erect, curved outwards in the upper portion, not exceeding 6 mm. in length.

Widely spread in South Africa, especially in mountainous parts.

A. Stem and branches woody.
  a. Leaf-pairs separated by short or elongated internodes. Leaves lanceolate, acute. Petals without mucro.
    1. Leaves green, often slightly pubescent. Petals 3–4 mm. long, 86. *Cr. Harveyi* Britt. et Bak. f.
    2. Leaves glauco-pulverulent.
      * Petals c. 5 mm. long. Calyx-lobes lanceolate, obtuse, 88. *Cr. punctulata* Schonl. et Bak. f.
      ** Petals c. 6 mm. long. Calyx-lobes obtuse . 87. *Cr. Kuhnii* Schonl.
  b. Leaf-pairs separated by very short internodes. Leaves ovate-lanceolate, subacute. Petals mucronate. Sepals nearly linear, at the apex bluntly mucronate . . . . 91. *Cr. ericoides* Haw.
B. Stem and branches subcarnose. Leaves narrowly oblong, attenuate at the base and apex . . . . 90. *Cr. parvisepala* Schonl.
C. Stem and branches carnose, subdichotomously branched. Leaves lanceolate, acute . . . . 89. *Cr. sarcocaulis* E. et Z.

Cymosa group (*Marginales* Harv. in Fl. Cap. p. pte.). Xerophytic laxly leafy subshrubs with woody stem and branches. Leaves sessile, connate, more or less flattened, on the margin papillose-ciliate, rarely setose on the surface. Inflorescence terminal, cymose-corymbose, the leaves on the branches usually decreasing in size upwards without the formation of a distinct peduncle. Petals erect, curving outwards in the upper part, 3–8 mm. in length, with or without a mucro.

From Clanwilliam in the coast districts to the Humansdorp div.

A. Leaves narrow, linear or lanceolate, acute or subacute.
  a. Flowers white, petals not exceeding 4 mm. in length . 92. *Cr. cymosa* L.
  b. Flowers creamy white, petals 6–8 mm. long.
    1. Inflorescences terminal, peduncles, pedicels, and bracts white-setose, 93. *Cr. flava* L.
    2. Inflorescences terminal or lateral, glabrous, 94. *Cr. Burmanniana* D. Dietr.
B. Leaves oblong, tongue-shaped or spathulate. Stem decumbent at base, with ascending simple branches, glabrous . . . 95. *Cr. dejecta* Jacq.
C. Leaves ovate or oblong, stem erect, simple, scabrous above, 96. *Cr. albiflora* Sims.
D. Leaves obovate or ovate. Stem diffusely branched, stem and branches glabrous, 97. *Cr. rubricaulis* E. et Z.

Scabra group (*Squamulosae* Harv. in Fl. Cap., ii, p. pte.). Xerophytic subshrubs with woody stem and branches, rarely (*Cr. dregeana*) subherbaceous.

Stem, branches, and leaves more or less papillose-hispid or minutely strigillose. Leaves connate or subconnate. Flowers on the branches in sessile or subsessile cymose-corymbose terminal inflorescences. Petals

erect, recurved in the upper part, mucronate, 3–6·5 mm. long. Styles subulate. Squamae minute.

Mostly restricted to S.W. Cape Province, one species in Pondoland and Natal (to which might perhaps be added a second: *Cr. recurva* N. E. Br.). Perhaps not a very natural group.

A. Stem, branches, and leaves densely clothed with elongated papillae.
  a. Leaves narrow, linear or linear-lanceolate . . . 98. *Cr. scabra* L.
  b. Leaves ovate-oblong or ovate. Stem slender, diffusely branched, 104. *Cr. dregeana* Harv.
B. Papillae fewer and very small.
  a. Leaves subulate subsemiterete, scabrous on the margin, 3–6 mm. long, 99. *Cr. pruinosa* L.
  b. Leaves ovate, acute, trigonous, ciliate on the margin, c. 3 mm. long, 100. *Cr. divaricata* E. et Z.
C. Stem and branches minutely albo-strigillose.
  a. Lower leaves linear, the upper subovate, all keeled or trigonous, ciliate on the margin, 3–5 mm. long . . . . 101. *Cr. Whiteheadii* Harv.
  b. Leaves ovate or ovate-lanceolate, acute or subobtuse, very convex on the back, the lower 7–12 mm. long, upper c. 4 mm. long, margin not ciliate, 103. *Cr. pallens* Schonl. et Bak. f.
D. Subglabrous, oblong lanceolate leaves scabrid with ciliate margin when young, 102. *Cr. petraea* Schonl.

Southi group. A subshrub with woody stem, fairly richly subdichotomously branched. Branches fairly densely covered with flat leaves which are about 13 mm. long, ovate-lanceolate, acutely mucronate, vaginate, papillose-ciliate on the margin. Flowers white, crowded at the end of the branches in cymose-corymbose inflorescences. Styles shortly subulate.

A single species found in S.E. Cape Province to an altitude of about 4000 feet.

In aspect somewhat like *Cr. Harveyi* Britt. et Bak. f.

107. *Cr. Southi* Schonl.

Perfoliata group (*Glaucinae* Harv. in Fl. Cap., ii, 332). Robust, succulent, subsimple subshrubs, often reaching a height of 2·5 feet, leafy throughout. Leaves connate, pulverulent glaucous, falcate or lanceolate, smooth-edged. Inflorescences terminal and lateral in the upper portions of the stem, densely much branched, cymose-cormybose. Petals white or more or less red, suberect. Styles subulate. Squamae minute.

From the karroid scrub of S.E. Cape Province to Natal and Barberton.

A. Leaves oblong, obliquely falcate, subobtuse . . 106. *Cr. falcata* Wendl.
B. Leaves lanceolate, acuminate, concave above . . 105. *Cr. perfoliata* L.

Vaginata group. Perennial herbs often with a woody rootstock, frequently reaching in their usually unbranched annual shoots a height of

3 or 4 feet. Internodes often papillose. Leaves more or less vaginate, flattish, lower always more than 3 cm. in length, papillose-ciliate on the margin and with the surfaces glabrous or more or less papillose or papillose all over. Petals erect or erecto-patent. Styles subulate, much shorter than the ovaries. Squamae minute.

Mostly found in grass veld in the S.E. portions of South Africa, especially in the mountainous parts, extending to Tropical Africa and Asia.

A. Leaves flattish.
  a. Margin of the leaves entire, ciliate.
    1. Petals yellow or yellowish. Margin of sepals glabrous.
      α. Internodes glabrous. Sepals about ½ the length of petals. Petals oblong . . . . . . 108. *Cr. vaginata* E. et Z.
      β. Internodes subglabrous. Sepals about ⅔ the length of the broadly oblong petals . . . . . . 110. *Cr. drakensbergensis* Schonl.
    2. Petals white, rosy or deep red, sepals usually ciliate on the margin.
      α. Leaves fairly even in size, only diminishing slightly from below upwards, ovate, subacute or obtuse, cuneate at base, 111. *Cr. natalensis* Schonl.
      β. Leaves diminishing considerably in size from below upwards, acute, usually lanceolate, never ovate.
        * Sepals glabrous, ovate or triangular.
          † Sepals about ⅓ the length of the petals. Marginal cilia of the leaves narrow and sharp-pointed, 113. *Cr. acinaciformis* Schinz.
          †† Sepals about ½ the length of the petals. Marginal cilia of the leaves rounded, papillosae . 112. *Cr. spectabilis* Schonl.
        ** Sepals glabrous or irregularly and sparsely ciliate on the margin, oblong-lanceolate, ⅔ to ⅘ the length of the petals, 109. *Cr. abyssinica* A. Rich.
        *** Sepals ciliate on the margin. Length of sepals very variable. Petals usually deep red . . . . . 114. *Cr. rubicunda* E. Mey.
  b. Margin of the leaves crenulate . . . . . 119. *Cr. crenulata* Thunb.
B. Leaves very convex on the back, lanceolate acuminate, often recurved, lowest over 2 cm. long. Stem leaves and pedicels covered with reflexed white hairs, 115. *Cr. recurva* N. E. Br.

Ramuliflora group (*Marginales* Harv. in Fl. Cap., ii, 333, p. pte.). Perennial herbs usually with a rootstock from which simple or sparsely branched shoots arise annually, rarely with trailing or decumbent stem. Leaves slightly connate, broad, flattish, with marginal papillae and often more or less papillose-setose on the surfaces. Flowers in terminal thyrsoid or more rarely cymose-corymbose or subcapitate inflorescences. Petals white or red, erect, recurved at the apex, with a small mucro. Styles shortly subulate. Squamae minute.

Widely spread in S.E. Cape Province, extending to Natal, the Transvaal, and Tropical Africa. The western limit seems to be the Zuurberg range in the Alexandria div. of the Cape Province. The delimitation of the species leaves still much to be desired, but can only be worked out satisfactorily

by cultivating a large number of what are now considered varieties of *Cr. ramuliflora* Link et Otto.

A. Shoots upright.
  a. Petals not less than 5 mm. long.
    1. Leaves broadly ovate, subacute or acute or elliptic, oblong or obovate, subacute or obtuse, rarely subrotund, calyx-lobes rough-edged, usually glabrous on the surface . . 117. *Cr. ramuliflora* Link et Otto.
    2. Leaves oblong-lanceolate. Calyx-lobes ½ the length of the petals, rough on edge and keel . . . . . . 119. *Cr. Meyeri* Harv.
    3. Leaves ovate or ovate-lanceolate. Calyx-lobes subglabrous, nearly ⅜ the length of the petals. Papillae on the margin of the leaves thicker and shorter than in allied species . . . 120. *Cr. Peglerae* Schonl.
  b. Petals about 3·5 mm. long . . . . . 121. *Cr. rubescens* Schonl.
B. Trailing or decumbent. Leaves subrotund or broadly ovate, calyx-lobes covered with white bristles . . . . . . 118. *Cr. lasiantha* E. Mey.

Setulosa group (*Marginales* Harv. in Fl. Cap., ii, 334, p. pte.). Small perennial herbs, chiefly branched from the sometimes subligneous base, rarely exceeding 10 cm. in height. Branches leafy, more or less hispid or glabrous. Leaves often congregated at the base and subdistant higher up, subconnate or free, succulent, often flattish, on the margin usually conspicuously ciliate, with glabrous or pubescent or hispid surfaces, rarely evenly pubescent all round. Flowers in terminal cymose-corymbose inflorescences, rarely singly or in pairs. Petals white or more or less red, erecto-patent, often with a small mucro. Styles small, subulate. Squamae minute.

Chiefly distributed in the mountainous parts of S.E. Cape Province, Natal, and the Transvaal, extending westwards to the mountains of the Karroo and the S.W. Protectorate. A satisfactory delimitation of some of the species is impossible when dried material only is available. Especially the forms placed under *Cr. setulosa* will repay further study with the aid of live material.

A. Leaves distinctly ciliate on the margin.
  a. Flowers in terminal, cymose-corymbose inflorescences, rarely paniculate.
    1. Leaves 1·5–7 mm. long and nearly as thick, subacute, mucronate, glabrous except for the sparingly ciliate margin, with a row of 3–5 red spots along the margin. Plant 1–2 in. high . . . 122. *Cr. sedifolia* N. E. Br.
    2. Leaves punctate above, oblong or linear-lanceolate or sublinear, acute or subacute, flat on the upper surface, very convex on the lower. Inflorescence often paniculate or thyrsoid . 124. *Cr. Schmidtii* Reg.
    3. Leaves flat or flattish.
      α. Lower leaves spathulate, obtuse. All leaves pale green with almost black blotches. Flowering branches often much elongated,
      123. *Cr. Cooperi* Reg.
      β. Leaves unspotted, often ovate-lanceolate, subacute or acute,
      125. *Cr. setulosa* Harv.

b. Flowers singly or in pairs in the forks of the ramifications of the branches,
126. *Cr. barklyana* Schonl.

B. Leaves subtrigonous, white, subtuberculate, not ciliate. Plant 1¾–2 in. high,
127. *Cr. densa* N. E. Br.

Sediflora group (*Squamulosae* Harv. in Fl. Cap., ii, 334, p. pte.). Thin-stemmed, laxly branched subshrubs. Branches decumbent or ascending, leafy throughout. Leaves flat, slightly fleshy, scabrous or ciliate on the margin. Flowers white, small, in usually lax, cymose-corymbose terminal inflorescences. Styles small, subulate. Squamae minute.

In damp situations on rocky ground—from the higher mountains of S.E. Cape Province to Natal.

A. Leaves 1–2 cm. long, nearly free, linear-lanceolate or oblong, acuminate at apex and attenuate at the base. Calyx-lobes ½ the length of petals or slightly more,
128. *Cr. sediflora* E. & Z.

B. Leaves 1·5–2 cm. long, distinctly connate, forming a sheath 2–3 mm. long, linear-lanceolate, acuminate. Calyx-lobes less than ½ the length of the petals,
131. *Cr. tenuifolia* Schonl.

C. Leaves 5–10 mm. long, connate, lowest ovate acute, uppermost lanceolate,
129. *Cr. amatolica* Schonl.

D. Lower leaves up to 5 cm. long, upper smaller, slightly connate, broadly lanceolate or oblanceolate, acuminate . . . 130. *Cr. Flanagani* Schonl. et Bak. f.

Quadrangularis group. Small, succulent perennial herbs, richly branched from the base. Leaves usually densely congregated, often forming a quadrangular short column, sessile, connate, ovate or obovate, or subovate, frequently subplicate, glabrous on both surfaces, on the margin papillose-ciliate. Inflorescences terminal, pedunculate, rarely subsessile, few-flowered cymose-corymbose or more richly flowered subspicate. Petals white, erect, slightly spreading at the top, minutely mucronate, not exceeding 5 mm. in length. Styles very small, subulate. Squamae somewhat larger than in preceding group.

One species in the Karroo, one near Middledrift (S.E. Cape Province), two in the Transvaal.

A. Styles erect or suberect.

a. Leaves broadly ovate, acute or subacute. Sepals lanceolate, subacute, carinate and sparsely pubescent on the back, ciliate on the margin,
132. *Cr. quadrangularis* Schonl.

b. Leaves broadly obovate, obtuse or subacute. Sepals lanceolate, obtuse, minutely papillate on the margin . . . 134. *Cr. Mossii* Schonl.

c. Leaves broadly obovate. Sepals lanceolate, subobtuse, carinate and pubescent on the back, ciliate on the margin . . . 135. *Cr. compacta* Schonl.

B. Styles (very short) almost horizontal . . . 133. *Cr. socialis* Schonl.

Rosularis group (*Rosulares* Harv. in Fl. Cap., ii, 334). Perennial succulent herbs, frequently with a distinct rhizome or forming runners.

Leaves rosulate, papillose-ciliate on the margin, otherwise glabrous. Inflorescences pedunculate, paniculate or thyrsoid, rarely capitate. Petals erect or erecto-patent, minutely mucronate. Styles shortly subulate. Squamae minute.

Mostly in shady rocky places in the coast districts from Swellendam to Natal and the Umbombolo range, also at Oudtshoorn, Cathcart, Beaufort West, and Graaff Reinet.

Cr. Aliciae Hamet in Bull. de la Soc. Bot. de France, cv (1908), 710, from China, which the author considers to be close to *Cr. indica*, is placed by him under Harvey's *Rosulares*.

A. Petals suberect, sometimes curved outwards in the upper portion. Plants very rarely with runners.
  a. Inflorescence paniculate or thyrsoid.
    1. Leaves spathulate-obovate or oblong, obtuse, anthers yellow, 136. *Cr. rosularis* Harv.
    2. Leaves oblong cuneate, ovate or obovate, cuneate at the base, anthers red. 137. *Cr. intermedia* Schonl.
  b. Inflorescence with 1 or 3 terminal small heads . 139. *Cr. Gillii* Schonl.
B. Petals curved outwards below the middle. Plants with runners, 138. *Cr. orbicularis* L.

Turrita group (*Thyrsoideae* Harv. in Fl. Cap., ii, 334). Succulent perennial herbs, branching from the base, Leaves either basal and rosulate or subdistant, gradually diminishing in size upwards, usually ciliate on the margin, glabrous or papillose on the surface. Inflorescence thyrsoid.

Petals usually white, rarely yellowish, erect or recurved at the apex, usually with a distinct small mucro. Carpels small, styles usually very small or absent, rarely distinctly subulate. Squamae small.

Widely spread in South Africa, especially in dry parts, apparently absent from the coast districts of S.W. and W. Cape Province.

Members of this group may be said to lead on the one hand to sect. *Sphaeritis*, on the other to sect. *Globulea*.

A. Petals suberect, often slightly incurved. Styles very short. Stigmata terminal.
  a. Leaves evenly distributed around the stem, either rosulate or gradually diminishing in size from below upwards.
    1. Cymules sessile.
      * Leaves (on the surface), stem and peduncle glabrous or subglabrous, 140. *Cr. turrita* Thunb.
      ** Leaves (on the surface), stem and peduncle papillose, 143. *Cr. albanensis* Schonl.
      *** Leaves on the surface subglabrous, stem and peduncle densely pubescent, 144. *Cr. nodulosa* Schonl.
    2. Cymules few-flowered, stalked. Leaves evidently tumid, glabrous on the surface, stem glabrous . . . . . 149. *Cr. Engleri* Schonl.

b. Leaves obliquely subdistichous, gradually decreasing in size upwards.

1. Leaves oblong-lanceolate, acute, retrorsely papillose-ciliate on the margin, 141. *Cr. subbifaria* Schonl.
2. Leaves broadly linear or subattenuate, not ciliate on the margin, 142. *Cr. inamoena* N. E. Br.

B. Petals suberect. Styles distinct, shortly subulate. Stigmata dorsal, subterminal. Leaves in a basal rosette, tumid, spathulate subrotund, over 3 cm. long, 151. *Cr. Broomii* Schonl.

C. Petals recurved at the apex. Styles very short, but distinct.

a. Leaves in a dense, basal, subhemisphaerical rosette which does not exceed 3–4 cm. in diam.

1. Margin of leaves densely papillose-ciliate, 145. *Cr. hemisphaerica* Thunb.
2. Margin of leaves with longish white hairs . . 146. *Cr. barbata* L.

b. Leaves subdistant, lanceolate acute or oblong acuminate, rarely subcordate acuminate, unspotted or punctate.

1. Petals 2·5–3 mm. long . . . 147. *Cr. corymbulosa* Link et Otto.
2. Petals 4 mm. long . . . . . . 148. *Cr. brevistyla* Bak. f.

c. Leaves subdistant, oblong-cuneate obtuse or acute, tumid, light green, spotted with dark green. Petals 4 mm. long . . 150. *Cr. maculata* Schonl.

Exilis group (*Squamulosae* Harv. in Fl. Cap., ii, 334, p. pte.). Perennial herbs, not exceeding 6 cm. in height, with fleshy stem branching from the base, closely leafy. Leaves thick, fleshy, densely covered with minute greyish papillae. Inflorescence pedunculate, cymose-corymbose. Petals erect, slightly recurved at the apex, with a small mucro, white or yellowish. Styles subulate, nearly the length of the ovaries. Squamae small.

Confined to Namaqualand and the S.W. Protectorate.

Leaves oblong, c. 1·2 cm. long . . . . . . 152. *Cr. exilis* Harv.
Leaves ovate acute, attenuate at the base, 1·6 cm. long . 153. *Cr. garibina* Schonl.
Leaves deltoid-ovate, subacute, c. 1 cm. long . . 155. *Cr. Luederitzi* Schonl.
Leaves subglobose, ovate subacute, c. 1 cm. long, 154. *Cr. klinghardtensis* Schonl.

Arta group (*Imbricatae* Harv. in Fl. Cap., ii, 334, p. pte.). Perennial herbs rarely exceeding 15 cm. in height. Stem fleshy, rarely subligneous, usually branched from the base, the branches bearing leaves which are frequently densely imbricated and never having long internodes. Leaves thick, fleshy, glabrous, glauco-pulverulent, pubescent or cinereo-papillose. Inflorescence on a slender peduncle bearing subcorymbose or subcapitate cymes. Flowers small, petals whitish, erect, sometimes connivent at the apex, sometimes more or less recurved at the apex, with a small mucro (always ?). Stamens and carpels much smaller than the petals. Stigmata sessile or subsessile, terminal. Squamae conspicuous. Confined to Namaqualand and the S.W. Protectorate.

A. Leaves exceeding in length considerably double their greatest diameter,
168. *Cr. grisea* Schonl.

B. Leaves in length less than twice their diameter.

a. Leaves globose or subglobose or oblong-globose, more or less flattened on the inner surface, sometimes approaching a semiterete condition.

1. Leaves subtessellate, glaucous, glabrous . . 159. *Cr. globosa* N. E. Br.
2. Leaves green, glabrous, inflorescence subcapitate (petals more recurved than in any allied species), peduncle about 2 cm. long,
166. *Cr. elegans* Schonl. et Bak. f.
3. Leaves green, glabrous. Peduncle 4–6 cm. long. Inflorescence lax,
165. *Cr. mesembrianthoides* Schonl. et Bak. f.
4. Leaves ashy glaucous, subtessellate, coarsely papillose,
164. *Cr. hottentotta* Marl. et Schonl.
5. Leaves ashy glaucous, minutely pubescent . 157. *Cr. Bakeri* Schonl.

b. Leaves deltoid ovate.

1. Leaves not densely imbricate and not connate . 158. *Cr. humilis* N. E. Br.
2. Leaves densely imbricate and connate.
* Largest leaves 1·4 cm. long, greatest diam. more than half the length,
160. *Cr. cornuta* Schonl. et Bak. f.
** Largest leaves rarely exceeding 1 cm. and barely half the length in greatest diam. . . . . 167. *Cr. Dinteri* Schonl.

c. Leaves deltoid or subdeltoid obtuse, densely imbricate.

1. Stem laxly branched above the base 161. *Cr. columella* Marl. et Schonl.
2. Stem branched from the base.
* Leaves prominently tessellate . . . 162. *Cr. deceptrix* Schonl.
** Leaves not tessellate.
† Leaves dorsally subcarinate, slightly and gradually narrowed towards the apex . . . . 156. *Cr. arta* Schonl.
†† Leaves quite round on the back and quite obtuse, evenly rounded at the apex . . . . 163. *Cr. Alstoni* Marl.

Argyrophylla group. Succulent, sparingly branched subshrubs, rarely exceeding 20 cm. in height. Stem fleshy or subligneous. Leaves connate or nearly free, rosulate or subdistant, almost always pubescent. Flowers in dense cymules arranged in subcorymbose, paniculate, or subspicate, pedunculate or sessile inflorescences. Petals white or whitish, erect, slightly recurved at the apex, with small or rudimentary mucro. Styles very short or practically absent. Sigmata terminal, or subdorsal. Squamae small.

One species common in the Transvaal, extending to Rhodesia and Swaziland, the others in the eastern Karroo extending to Cala.

A. Leaves flattish, subrosulate, obovate-cuneate, obtuse, up to 3 cm. long,
169. *Cr. argyrophylla* Diels.

B. Leaves flattish, dorsally slightly convex, oblong, subacute, subdistant, c. 1·5–2 cm. long. Sepals about ⅔ the length of the petals,
170. *Cr. pachystemon* Schonl. et Bak. f.

C. Leaves subsemiterete, oblong, subacute, subdistant, usually 1 cm. long or less, rarely slightly longer. Sepals nearly the length of the petals,
171. *Cr. Ernesti* Schonl. et Bak. f.

D. Leaves ovoid, acute or subacute . . . . . 173. *Cr. lanuginosa* Harv.
E. Leaves subsemiterete, obovate, obtuse, about 1 cm. long. Inflorescence subspicate. 172. *Cr. decidua* Schonl.

SECT. V. SPHAERITIS (E. et Z. in Enum., 299, as a genus; sect. *Sphaeritis*, *Margarella*, and *Pachyacris* Harv. in Fl. Cap., ii, 336).

Xerophytic subshrubs with ligneous stem or perennial succulent herbs of various habits. Inflorescences usually pedunculate, cymose-corymbose, capitate or thyrsoid. Petals slightly reflexed in their upper portion, white or with a yellowish tinge, slightly folded along the median line in the upper part, or much narrowed in the upper part and folded, or this upper narrow part becoming more or less concrete, rarely with a small mucro, more rarely with a conspicuous subglobose mucro. Stigmata subsessile. Squamae comparatively large.

With the exception of a (to me) doubtful occurrence of one species in Swaziland, this section is confined to the Cape Province, bounded roughly in the east by a line from Naauwpoort to the Bathurst div.

Ramosa group. Subshrubs with leafy branches, up to about 2 feet in height. Stem and older branches subligneous, efoliate. Leaves numerous, usually densely and evenly spaced on the ultimate branches. Inflorescences terminal, capitate or cymose-corymbose, without or with only a short peduncle.

South-western as far as the Uitenhage div.

A. Leaves hispid . . . . . . 178. *Cr. hispida* Schonl. et Bak. f.
B. Leaves glabrous (except for marginal papillae).
 a. Inflorescences capitate.
  1. Leaves sessile.
   * Leaves narrowly lanceolate acute.
    0. Petals distinctly narrowed in the upper part. Sepals glabrous on the margin or minutely denticulate . 174. *Cr. ramosa* Thunb.
    00. Petals barely contracted in the upper part. Sepals ciliate on the margin . . . . 180. *Cr. Rudolfi* Schonl. et Bak. f.
   ** Leaves oblong or oblong ovate . 179. *Cr. leucantha* Schonl. et Bak. f.
   *** Leaves oval acute . . . . . . 176. *Cr. fastigiata* Schonl.
  2. Leaves subpetiolate . . . . . . 177. *Cr. Rustii* Schonl.
 b. Inflorescence corymbose. Leaves oblong-lanceolate, up to 5 cm. long, 175. *Cr. multiflora* Schonl. et Bak. f.

Clavifolia group. Branched subshrubs rarely more than 1 foot in height. Stem and older branches subligneous, efoliate. Leaves congregated at the base of the ultimate branches, succulent, usually flattish, always obtuse or subobtuse, with or without marginal ciliae. Inflorescences paniculate or corymbose, rarely thyrsoid, with capitate cymules, rarely reduced to a single capitate cymule, with distinct peduncles bearing at intervals reduced leaves.

South-western and western.

A. Petals with a distinct subglobose mucro just behind the apex,
183. *Cr. anomala* Schonl. et Bak. f.
B. Petals without mucro or mucro only faintly indicated.
a. Leaves not plainly ciliate on the margin.
1. Leaves glabrous or minutely puberulous . . . 181. *Cr. clavifolia.*
2. Leaves sericeo-pubescent . . . . 182. *Cr. sericea* Schonl.
b. Leaves distinctly papillose ciliate . . . . . 184. *Cr. ciliata* L.

Virgata group. Shrublets with thick, more or less semiterete, glabrous or subglabrous leaves, the pairs being usually separated by distinct internodes. Inflorescence paniculate or corymbose, cymules capitate, usually pedunculate, or single capitate pedunculate cymules.

Central and western parts of the Cape Province.

A. Richly squarrosely branched (similar to *Cr. Harveyi*) . 191. *Cr. remota* Schonl.
B. Unbranched or branches very long (over 40 cm.) . 190. *Cr. serpentaria* Schonl.
C. Laxly branched.
a. Branches, leaves and peduncles cano-puberulous . 186. *Cr. incana* Harv.
b. Branches, leaves and peduncles with short stiff pubescence,
189. *Cr. Purcellii* Schonl.
c. Branches, leaves and peduncles glabrous or subglabrous, rarely softly pubescent.
1. Leaves linear-trigonous, glabrous, with smooth margin,
185. *Cr. virgata* Harv.
2. Leaves semiterete-ovate or oblong, obtuse, scaberulous or puberulous,
187. *Cr. subaphylla* Harv.
3. Leaves subsemiterete, oblanceolate or oblong linear, very minutely pubescent,
188. *Cr. Smutsii* Schonl.

Trachysantha group. A sparingly branched subshrub, usually about 25–30 cm. high, with approximate or somewhat distant leaf-pairs. Leaves semiterete, acute or subobtuse, densely covered with retrorse, very acute, setose papillae, gradually decreasing in size on the terminal peduncle. Flowers in cymose-corymbose (rarely subcapitate) terminal clusters. Petals with a narrow fleshy apex.

Only found in the Uitenhage, Albany, and Bathurst divs.

Only one species (variable especially in size and shape of leaves),
192. *Cr. trachysantha* (E. & Z.) Harv.

Tomentosa group. Perennial herbs, sometimes with subligneous base; leaves radical or subradical, flattish, covered with hairs or bristles, rarely only with marginal ciliae. Inflorescence terminal (rarely also lateral), pedunculate, usually with a few pairs of empty bracts, terminating in a thyrsus bearing pairs of capitate, rarely stalked cymules.

The delimitation of the species in this group may have to be modified when fuller material is available.

From the dry parts of Cape Province, in the neighbourhood of Laings-

burg westwards to the Cape Peninsula, and Namaqualand, extending northwards to the S.W. Protectorate (also in Swaziland ?).

A. Leaves glabrous on the surface, 194. *Cr. interrupta* E. Mey. var. *glabrifolia* Schonl.
B. Leaves densely hairy.
  a. Empty bracts on the peduncle oblong, subacute . 193. *Cr. tomentosa* Thunb.
  b. Empty bracts on the peduncle obovate, obtuse . 194. *Cr. interrupta* E. Mey.
  c. Empty bracts on the peduncle obovate, cuneate at the base, obtuse or subacute, 195. *Cr. scalaris* Schonl. et Bak. f.

Namaquensis group. Succulent perennial herbs branched from the base, never more than 15 cm. high. Leaves thick, usually covered with papillae or hairs. Inflorescence terminal, pedunculate. Flowers sessile or subsessile in capitate cymules, which are either single and terminal or few near the top of the peduncle. This group is allied to the *Arta* group of sect. *Campanulatae*.

Western parts of Cape Province and Karroo.

A. Petals not distinctly contracted and canaliculate in the upper part. Papillae on leaves dense, thick, short, white tipped . . . . 197. *Cr. tecta* Thunb.
B. Petals distinctly contracted and canaliculate in the upper part.
  a. Leaves densely covered with short thick papillae, 196. *Cr. namaquensis* Schonl. et Bak. f.
  b. Leaves retrorsely hispid . . . 200. *Cr. biconvexa* (E. & Z.) Harv.
  c. Leaves densely covered with retrorse, very acute papillae, 199. *Cr. hystrix* Schonl.
  d. Leaves glabrous . . . . 198. *Cr. hirtipes* Harv.

SECT. VI. GLOBULEA Harv. in Fl. Cap., ii, 336 ; Haw. in Syn. Pl. Succ., 60 (as genus) ; Schonl. in Engl. Bot. Jahrb., xlv, 244.

Succulent, xerophytic perennial herbs or sub-shrubs with subrosulate leaves or leafy branches. Inflorescences usually only terminal, pedunculate. Flowers usually in dense cymules which are variously arranged. Calyx-lobes thick, not much shorter than the white or yellowish, imbricate petals which are broadly ovate or panduriform in the upper part, contracted at the base and united to form a short tube. The apex of the petals is incurved and bears on the back a comparatively large, thick, ovate or subglobular mucro. The carpels are much shorter than the stamens. The styles are very short. The stigmata are often subdorsal. The squamae are $\frac{1}{4}$–$\frac{1}{2}$ the length of the ovaries.

Widely distributed in dry localities in Cape Province from Namaqualand to Basutoland and the O.F.S., and in the coast districts to Kentani.

Some of the species here recognised are extremely variable in their vegetative organs. Possibly hybridisation may account for some of the difficulties encountered when trying to find specific limits in some cases. The floral characters are fairly uniform and can seldom be utilized to help in distinguishing species.

A. Suffrutices, often with ligneous stem. Branches with subdistant leaf-pairs.
  a. Leaves flattish, glabrous or subglabrous, sometimes ciliate on the margin, usually cultrate, obovate or obovate-oblong, rather stiff.
    α. Petals not denticulate at the apex. Flowers in dense or loose cymules. Sometimes only 1 terminal head (close on 2 cm. in diam.), but generally total inflorescence paniculate. Branches ascending or upright. Leaves 2–3 cm. long, rarely longer . . . . . . 201. *Cr. cultrata* L.
    β. Petals denticulate at the apex. Flowers in dense cymules, rarely exceeding 5 mm. in diam. Cymules variously arranged. Branches decumbent, sometimes forming small runners. Leaves 1–1·5 cm. long, 202. *Cr. radicans* D. Dietr.
  b. Leaves minutely puberulous, tumid, obliquely oblong-lanceolate or obliquely lingulate, subacute or obtuse, flat on the upper side, slightly convex on the lower, usually about 2 cm. long . . . 203. *Cr. fragilis* Schonl.
  c. Leaves distinctly pubescent, strongly convex on both surfaces, tumid, obovate (often subpetiolate), obtuse or subacute . . 204. *Cr. Rogersii* Schonl.
  d. Leaves minutely pubescent, subsemiterete, lanceolate or oblong, 205. *Cr. mollis* Thunb.

B. Perennial herbs branched from the base. Stem thick, decumbent or usually short, upright, rarely slightly branched higher up. Leaves approximate, usually distinctly rosulate.
  a. Leaves flattish on both surfaces.
    α. Leaves glabrous, cartilagineo-ciliate on the margin, lanceolate-oblong or obliquely cultrate, subacute or obtuse . . 206. *Cr. obvallata* L.
    β. Leaves glabrous, smooth-edged, broadly obovate or subrotund, usually very obtuse . . . . 207. *Cr. platyphylla* Harv.
  b. Leaves broadened, distinctly convex on both surfaces or at all events on the lower.
    α. Leaves glabrous.
      1. Leaves clavate, about 1 cm. in length . 212. *Cr. clavata* N. E. Br.
      2. Leaves subovate, lanceolate or linear-lanceolate, acute or subacute, 210. *Cr. erosula* N. E. Br.
    β. Leaves minutely pubescent, spathulate or subobovate up to 3·5 cm. in length, 209. *Cr. Rattrayi* Schonl. et Bak. f.
    γ. Leaves more or less canescent, obovate cuneate, sometimes oblanceolate or (in the type) sublinear, obtuse or subacute, 2–7·5 cm. long, 208. *Cr. cephalophora* Thunb.
    δ. Leaves pubescent-canescent, obovate cuneate or oblong, not exceeding 1·4 cm. in length . . . . . 211. *Cr. Fergusoniae* Schonl.

C. Leaves semiterete, subulate, acute, more or less channelled above.
    α. Cymules often stalked, the pairs distinctly separated from one another.
      1. Leaves glabrous or subpubescent . . 213. *Cr. nudicaulis* L.
      2. Leaves covered more or less with bristle-like hairs, 214. *Cr. hirta* Thunb.
    β. Cymules sessile, the pairs approximating one another, 215. *Cr. spicata* Thunb.

SECT. VII. PYRAMIDELLA (Harv. in Fl. Cap., ii, 336; Schonl. in Engl. Bot. Jahrb., xlv, 256).

Fleshy, monocarpic, perennial herbs. Leaf-pairs usually close together and thus forming a dense column or pyramid. Inflorescences terminal or

more rarely also lateral, capitate or subspicate. Petals white or reddish, connected at the base into a very distinct tube, lobes erecto-patent, sub-lanceolate or subspathulate, without mucro. Sepals much shorter than the petals. Stamens attached to the corolla-tube with short, free, filiform filaments. Carpels short. Styles very short. Squamae usually stipitate. Flowers sweet-scented.

This section is restricted to karroid localities in Central and Western Cape Province. There is some evidence to show that hybridisation is not uncommon in this section.

A. Stem simple or with very short branches.
- *a.* Leaves very fleshy, transversely subelliptical, obtuse, convex on the back, often with incurved margin. Whole plant before flowering more or less egg-shaped, 216. *Cr. columnaris* Thunb.
- *b.* Leaves similar to *Cr. columnaris*, but with a hyaline margin, forming a short subcylindrical column. Lobes of petals 10 mm. long, 218. *Cr. teres* Marl.
- *c.* Similar to *b*, but leaves without hyaline margin. Lobes of petals 5 mm. long, 219. *Cr. Barklyi* N. E. Br.
- *d.* Leaves broadly triangular, subacute, with the margin slightly incurved forming a cylindrical column . . . . . 220. *Cr. cylindrica* Schonl.
- *e.* Leaves triangular ovate, subacute, flattened, forming a 4-angled pyramid or column . . . . 221. *Cr. pyramidalis* Thunb.
- *f.* Leaves convex on the back, in outline ranging from ovate, obtuse or subacute to lanceolate subacute, not forming such a dense structure as in other species of this section . . . . 217. *Cr. congesta* N. E. Br.

B. Stem often branched, at all events in the floral region.
- *a.* Leaves triangular ovate, subacute . . 221. *Cr. pyramidalis* Thunb. var.
- *b.* Leaves deltoid at the base, attenuate in the upper portion, usually acute, 222. *Cr. alpestris* Thunb.
- *c.* Leaves deltoid or ovate, bluntish, gibbous on the lower surface, 223. *Cr. vestita* Thunb.

Sect. I. TILLAEOIDEAE Schonl. in Ann. Bolus Herb., ii, 41.

Helophytum group.

1. **Cr. natans** Thunb., Prodr. (1794), 54, Fl. Cap., ed. Schultes, 281; DC., Prodr., iii, 389; Schonl. in Ann. Bolus Herb., ii, 47, fig. 1 and pl. ii, fig. 1; *Cr. capensis* (L. f.) Schonl. in Engler and Prantl's Pflanzenfamilien (*Crassulaceae*).

Tillaea capensis L., Syst. Veg., xiv, 170; L. f. Suppl., 129.

T. inanis Steud., Nom., ed. 2, ii, 687 (ex Ind. Kew.).

T. elatinoides Walp., Rep., ii, 251.

T. filiformis Endl. (ex Walp., Rep., ii, 252).

T. fluitans Endl., *loc. cit.*

T. reflexa Endl., *loc. cit.*

Helophytum natans E. et Z., Enum., No. 1843; Harv. in Fl. Cap., ii, 328.

H. filiforme E. et Z., *loc. cit.*, No. 1844; *Cr. filiformis* D. Dietr. ?

H. fluitans E. et Z., *loc. cit.*, No. 1845.

H. reflexum E. et Z., *loc. cit.*, No. 1846.

? *H. natans β minus* E. et Z., *loc. cit.*, No. 1843.

? *Bulliarda filiformis* E. et Z., *loc. cit.*, No. 1850.

B. elatinoides E. et Z., *loc. cit.*, No. 1849.

Five different forms were distinguished by the writer in Ann. Bolus Herb., ii, 49.

In water and damp places in the southern coast regions of South Africa, penetrating far inland, Transvaal, East Africa, Australia. Type in Herb. Thunberg, Upsala.

2. **Cr. inanis** Thunb., Prodr. (1794), 54, Fl. Cap., ed. Schultes, 282; Schonl. in Ann. Bolus Herb., ii, 50, pl. ii, fig. 2.

Tillaea perfoliata Linn., Syst. Veg., xiv, 170; Linn. f. Suppl., 129.

Helophytum inane E. et Z., Enum., No. 1847 (also var. *latifolium* E. et Z.); Harv. in Fl. Cap., ii, 329.

Southern coast regions of South Africa, Transvaal, in water or damp places. Type in Herb. Thunberg, Upsala.

VAILLANTII group.

3. **Cr. papillosa** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 371; Schonl. in Ann. Bolus Herb., ii, 51, fig. 2 and pl. ii, fig. 3.

Cr. limosa Schonl. in Rec. Albany Mus., i (1903), 58.

Matroosberg, Seven Weeks Poort Mt., Sneuwberge, Andriesberg, Majuba Nek, Herschel district in muddy places. Type: (Marloth, 1999) in Herb. Albany Museum.

4. **Cr. Vaillantii** (Willd.) Roth in Enum. Pl. Phan. Germ., i, 992; Schonl. in Ann. Bolus Herb., ii, 51, fig. 3 and pl. ii, fig. 4.

Tillaea Vaillantii Willd., Sp. Pl., i (1797), 720.

T. rupestris Hochst., Verz.

T. aquatica Lam., Illustr., No. 1750, t. 50, fig. 1.

T. prostrata β Poir., Dict., 7, 674.

T. angustifolia Nutt. MS. in Torrey and Gray, Fl. of N. Am., i, 558.

T. viridis Wats.

Bulliarda Vaillantii DC. in Bull. Soc. Phil., No. 49, i (1803), Plantes Grasses, t. 74, Prodr., iii, 382; A. Rich., Fl. Abyss; Don, Gen. Syst., iii, 99; Ecklon and Zeyher, Enum., No. 1848; Harvey in Fl. Cap., ii, 329.

Tillaeastrum Vaillantii Britton in Bull. New York Bot. Gard., iii, 1.

T. viride Rose, *loc. cit.*, 2.

Sedum minimum, etc., Vaill., Paris, 181, t. 10, fig. 2 (ex DC.).

In water or on mud, widely distributed in South Africa, but always very local, also Kilimandjaro, Abyssinia, Mediterranean Region, Portugal, France, Austria, United States, and Mexico.

5. **Cr. decumbens** Thunb. (non E. et Z.) in Prodr. (1794), 54, Fl. Cap., ed. Schultes, 280; DC., Prodr., iii, 389; Schonl. in Ann. Bolus Herb., ii, 53, fig. 4 and pl. ii, fig. 5.

Bulliarda trichotoma E. et Z., Enum., No. 1851; Harvey in Fl. Cap., ii, 330.

Cr. Thunbergiana Roem. et Schult., Syst., vi, 733.

Cr. Leipoldtii Schonl. et Bak. f. in Journ. of Bot., xl (1902), 288.

Tillaea decumbens Willd. in Sp. Pl., i, 721.

T. trichotoma Walp. in Rep., ii, 251.

S.W. Cape Province from Calvinia through Clanwilliam and the Cape Peninsula to Port Elizabeth.

There are four sheets in Herb. Thunberg under *Cr. decumbens* representing three different species.

α is *Cr. brevifolia* (E. et Z.) Schonl.

β agrees sufficiently well with Thunberg's description of *Cr. decumbens* to be taken as the type.

γ and δ are *Dinacria filiformis* Harv. in Fl. Cap., ii, 331.

6. **Cr. Roggeveldii** Schonl. n. sp.

Annua glaberrima erecta vel suberecta e basi ramosa vel subsimplex sursum laxe ramosa internodiis elongatis. Folia patentia obovata obtusa basin versus attenuata connata. Flores tetrameri axillares et terminales fastigiata pedicellati, pedicellis filiformibus infra flores obconicis. Sepala basi breviter connata obovata obtusa. Petala quam sepala $\frac{1}{4}$ longiora late oblonga obtusa. Stamina quam petala minora. Ovaria obliqua dorso apicem versus subumbonata multiovulata stilis brevibus. Squamae late obcuneatae apice rotundatae.

Height about 7 cm. Leaves 5–7 mm. long, decreasing in size upwards. The two lower internodes 2–3 cm. long, upper much shorter. Calyx segments $1\frac{1}{2}$ mm. long. Petals 2 mm. long. Stamens about 1 mm. long.

This new species is allied to *Cr. decumbens* Thunb., but the obovate leaves distinguish it at once. It has also many points in common with *Cr. umbellata* Thunb., but this has quite a different habit, besides differing in many details.

Sneuw Krans, farm Uitkyk, Sutherland div., 1500 m., Oct., Marloth, 9910. Other specimens (collected in wet mud, stony plain towards Waterkloof, 1430 m., Sept., Marloth, 10413) cannot be separated specifically from those described above; the plants have a compact cushion-like growth, being much branched from the base; the internodes are much shorter (not

exceeding 1 cm.); the flowers are slightly smaller but agree well in general details.

7. **Cr. brevifolia** (E. et Z.) Schonl. (non Harv.) in Ann. Bolus Herb., ii, 54, pl. iv, fig. 6.

Bulliarda brevifolia E. et Z. in Enum. (1837), No. 1852; Harv. in Fl. Cap., ii, 330.

Tillaea brevifolia Walp. in Rep., ii, 251.

Damp places, S.W. Cape Province (Drege, 6884, etc.).

8. **Cr. langebergensis** Schonl.

Annua pusilla e basi ramosa diffusa, ramis ramulisque teretibus. Folia anguste obovata subacuta basi cuneata connata, inferiora 5–10 mm. longa, superiora minora. Flores tetrameri numerosissimi axillares et terminales pedicellis filiformibus quam folia longioribus. Calyx profunde quadrifidus, lobis $2\frac{1}{4}$ mm. longis oblongis acutis ad margines ciliatis. Corolla profunde quadrifida, petalis $2\frac{1}{4}$–$2\frac{1}{2}$ mm. longis ovato-lanceolatis subacutis. Stamina c. $1\frac{3}{4}$ mm. longa, filamentis filiformibus c. $1\frac{1}{2}$ mm. longis, antheris oblongis c. $\frac{1}{4}$ mm. longis. Carpidia 2 mm. longa, ovariis oblongis 1–4 ovulatis, stilis subulatis ovariis subaequilongis. Squamae breviter stipitatae superne dilatatae apice rotundatae et leviter emarginatae.

Wet flushes on the Langeberg, 900 ft., Sept., Dr. J Muir, 3354. This species comes close to *Cr. brevifolia* (E. et Z.) Schonl. (*Bulliarda brevifolia* E. et Z.), and is, like it, a small herb, only a few cm. high. It bears numerous comparatively large flowers, but its growth is more diffuse, petals and sepals are about of equal length, the latter are ciliate on the margin, the ovaries have fewer ovules. There are also other minor differences. It is even perhaps more closely allied to *Cr. decumbens* Thunb. This has multi-ovulate ovaries. Its calyx-lobes are a little different in shape and not ciliate. Type in Herb. Albany Mus.

Aphylla group.

9. **Cr. aphylla** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 371; Schonl. in Ann. Bolus Herb., ii, 54, fig. 5 and pl. iii, fig. 7.

Boontjes Rivier, Western Region, c. 700 m., Schlechter, 8664.

Type in Herb. Albany Mus. and Berlin.

Filicaulis group.

10. **Cr. expansa** (Dryand.) in Ait. Hort. Kew., i, 390; Willd., Sp. Pl., i, 1561; DC., Prodr., iii, 389; Harv. in Fl. Cap., ii, 354; Britten and Baker f. in Journ. of Bot., xxxv (1897), 483; Schonl. in Ann. Bolus Herb., ii, 55, fig. 6 and pl. iii, fig. 8.

Cr. filicaulis E. et Z. in Enum., No. 1883 ? ; Haw. in Phil. Mag. (1824), 186.

Cr. maritima Schonl. in Bull. de l'herb. Boiss., v (1897), 862.

Cr. parviflora E. Mey. in Herb. Drege.

Compare further my remarks in Ann. Bolus Herb., ii, 56, on *Cr. pulchella* Soland. in Ait. Hort. Kew., i, 392.

Bergius' specimens in Herb. Berol. from Zout River are labelled *Cr. expansa*, but belong to *Cr. Zeyheriana*.—Common in dampish places, often amongst short grass, in the coast districts from Little Namaqualand to Natal, and perhaps to Delagoa Bay, extending inland to Oudtshoorn, Beaufort West, and Queenstown, varying to a certain extent in the shape and thickness of the leaves, as also in the size of the flowers.

The specimens on sheets 30, 31 in Herb. Linnaeus, London, belong to *Cr. expansa*. They are marked "*pellucida*," but are not *Cr. pellucida* L. Bentham and Hooker have suggested that the genus *Dasystemon* DC. is based on *Cr. expansa*. This is not the case.

11. **Cr. browniana** Burtt-Davy in Flowering Plants and Ferns of the Transvaal and Swaziland (1925), 38.

Near Lydenburg, Jan., Wilms, 518, in Herb. Kew. Also in Rhodesia.

This is *Cr. furcata* Schonl. in S.A. Journ. of Science, xvii (1921), 188. I append the full diagnosis which I had drawn up, but which hitherto has not been published.

Herbacea humilis perennis radicibus fibrosis. Caulis rubescens subdichotome ramosus omnino foliatus teres dense pubescens, internodiis inaequalibus quam folia longioribus vel brevioribus. Folia decussata, leviter connata breviter petiolata vel sessilia, pubescentia, carnosula, lamina subplana obovata obtusa vel spatulata. Flores solitarii terminales et ex axillis foliorum superiorum pauci. Pedicellus filiformis pubescens post anthesin valde elongatus. Calycis tubus brevissimus, lobi lineares obtusi dorso convexi pubescentes. Petala sublibera quam sepala longiora alba ovata acuta erecto-patentia infra apicem dorso minutissime mucronulata et dorso versus apicem medio pubescentia. Filamenta alba applanato-subulata. Antherae late ovatae luteae. Stili albi subulati quam ovaria alba breviora. Ovaria ad margines interiores minutissime ciliolata. Squamae albae obcuneatae.

Height of plant about 5 cm. Internodes 6–15 mm. long. Lower leaves (including the short petiole) about 8 mm. long, 3–4 mm. broad. Pedicels (when fully elongated) about 20 mm. long. Calyx 2 mm. long (tube less than ½ mm.). Petals 3 mm. long. Carpels 2 mm. long.

The Downs, Pietersburg, Rogers ; Wylies Poort, Louis Trichardt, Pole Evans ; Bulawayo, Rogers, 13673 ; Matopos, Rogers, 7927 ; Palm Grove, Victoria Falls, Rogers, 5058. Specimens from Palm Grove, Victoria Falls,

Eyles, 1293, are more luxuriant, but cannot be specifically separated.—The species might also be placed near *Cr. silvatica* Licht.

12. **Cr. tenuis** Wolley Dod in Journ. of Bot., xxxix (1901), 399; Schonl. in Ann. Bolus Herb., ii, 57, fig. 7 and pl. iii, fig. 9.

Rocky places, Cape Peninsula, Malmesbury, Namaqualand, Roggeveld. Type: Wolley Dod, 3369, in Herb. Albany Mus., etc.

13. **Cr. oblanceolata** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 365; Schonl. in Ann. Bolus Herb., ii, 58, pl. iii, fig. 10.

Karreebergen, 1800 ft., Schlechter, 8306; ? Capetown, Wilms, 3198; near Nixon's cutting, Klipfontein, Namaqualand, c. 3000 ft., Aug., Bolus, 9516, in Herb. Berol.; hills, Botterkloof, W. Reg., 2300 ft., July, Schlechter, 10886.

Type: Schlechter, 8306, in Herb. Albany Mus., which in the British Museum is called *Cr. albicaulis* Harv.

14. **Cr. Lambertiana** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 371; Schonl. in Ann. Bolus Herb., ii, 58.

S.W. Cape Province, Calvinia. Type: Schlechter, 8539, in Herb. Albany Mus.

15. **Cr. uniflora** Schonl. n. sp.

Herbacea perennis nana glaberrima. Caulis reptans efoliatus radicibus filamentosis. Rami suberecti 2–3 cm. longi basi efoliati caeterum dense foliis quadrifariis tecti apice uniflori. Folia opposita sublibera rubriuscula squamis membranaceis albis laceratis tecta, carnosa, ambitu oblonga apice subobtusa, dorso convexa interdum subcarinata, inferiora 5 mm. longa, superiora gradatim minora. Flos terminalis pedicellatus, pedicello rubriusculo gracili 3–5 mm. longo. Tubus calycis brevissimus, lobis lanceolatis dorso convexis c. 3 mm. longis. Petala alba erecto-patentia lineari-oblonga, dorso apicem versus distincte carinata sed emucronulata c. 4 mm. longa. Filamenta subulata applanata c. 3 mm. longa, antheris basifixis late ovalibus luteis. Carpidia gracilia, ovariis c. 2 mm. longis, stilis distinctis c. 1 mm. longis, stigmatis parvis terminalibus. Squamae minutae subcarnosae late obcuneatae, apice leviter emarginatae.

Melkhoutfontein, Riversdale div., 600 ft., Dr. J. Muir, 6740, Sept. 1925.

The flowers of this species somewhat resemble those of *Cr. expansa*, to which it seems to be allied. The broken whitish skin on the leaves is evidently the cuticle which becomes detached. I think the flowers are always terminal on the branches, but are frequently thrown aside by a branch developing in the axil of one of the uppermost leaves and forming a sympodium. Vegetative reproduction evidently takes place as in *Cr. corallina* Thunb. by the branches becoming more and more horizontally placed by their weight and then rooting.

GLOMERATA group.

16. **Cr. glomerata** L., Mant. (1767), 60, Syst. Veg., ed. 14, 305; Bergius, Descr. Pl. Cap., 85; (Solander) in Ait. Hort. Kew., ed. 1, i, 392; Thunb., Prodr., 54, Fl. Cap., ed. Schultes, 281; Burm. f., Prodr., 8; Houttuyn, Linn. Pfl. Syst., vi, 280; Willd., Sp. Pl., i, 1556; Haw., Syn. Pl. Succ., 58, Rev. 12; DC., Pl. Gr., t. 57, Prodr., iii, 389; Harv. in Fl. Cap., ii, 352; Schonl. in Ann. Bolus Herb., ii, 59, fig. 8, pl. iv, fig. 11.

? *Cr. strigosa* Lam.; *Cr. scleranthoides* Burm. f., Prodr., 3; *Cr. glabra* Haw., Syn., 58, Rev., 12; DC., Prodr., iii, 389; Harv. in Fl. Cap., ii, 353; *Cr. capillacea* E. Mey. a (ex Harvey).

Thisantha glomerata E. et Z. in Enum., No. 1929; *Th. glabra* E. et Z., *loc. cit.*, No. 1931; *Th. patens* E. et Z., *loc. cit.*, No. 1930; *Th. strigosa* E. et Z., *loc. cit.*, No. 1932.

Common in sandy places in S.W. Cape Province (especially on the Cape Peninsula), near mouth of Slang River, and Humewood, near Port Elizabeth. Frequently represented in old herbaria, *e.g.* Herb. Linnaeus, Thunberg, Lamarck. *Thisantha scaberula* Kze. (ex horto Petrop. in Herb. Kew) appears to be this species with rather lanky growth.

17. **Cr. Zeyheriana** Schonl. in Ann. Bolus Herb., ii, 60, fig. 9, pl. iv, fig. 12.

Cr. decumbens Harv. (non Thunb.) in Fl. Cap., ii, 353.

? *Cr. glomerata* Berg., Pl. Cap., 85.

Thisantha decumbens E. et Z. in Enum., No. 1933.

In damp shady spots from Saldanha Bay to the Cape Peninsula and neighbourhood. Type: Z. 651.

18. **Cr. parvipetala** Schonl. in Rec. Albany Mus., ii (1913), 450; Ann. Bolus Herb., ii, 60, fig. 10.

Khamisberg, damp places beneath rock, Pearson, 6658, p. pte. Type in Herb. Albany Mus.

19. **Cr. albicaulis** Harv. in Fl. Cap., ii, 353; Schonl. in Ann. Bolus Herb., ii, 61.

Ezelsfontein, Namaqualand. Known to me only from the description. Type in Herb. Harvey, Dublin ?.

20. **Cr. hirsuta** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 365; Schonl. in Ann. Bolus Herb., ii, 62, fig. 11, pl. iv, fig. 13.

Messklip, Namaqualand, on hills, 2000 ft., Schlechter, 11283, p. pte. Type in Herb. Albany Mus., etc.

21. **Cr. minutiflora** Schonl. et Bak. f. in Journ. of Bot., xl (1902), 288; Schonl. in Ann. Bolus Herb., ii, 62, pl. iv, fig. 14.

Steinkopf, Namaqualand, on hills, Schlechter, 11496. Type in Herb. Albany Mus., etc.

22. **Cr. tenuipedicellata** Schonl. et Bak. f. in Journ. of Bot. xl (1902), 288; Schonl. in Ann. Bolus Herb., ii, 62, pl. iv, fig. 15.

On hills near Arakup (Western Region), 2300 ft., Schlechter, 11247. Type in Herb. Albany Mus., etc.

MUSCOSA group.

23. **Cr. filamentosa** Schonl. in Ann. Bolus Herb., ii, 63, pl. v, fig. 16.

Cr. muscosa Harv. (non Linn. nec Thunb.) p. pte. in Fl. Cap., ii, 351; ? *Cr. lycioides* E. Mey. ex Harv. in Fl. Cap., ii, 351.

Mountains of the Eastern Cape Province, Basutoland, Bloemfontein, Transvaal. Type: Hepburn, 1916, in Herb. Albany Mus.

24. **Cr. campestris** (E. et Z.) Harv. in Fl. Cap., ii, 351 (an *Cr. campestris* Endl. in Walp. Rep., ii, 253 ?); Schonl. in Ann. Bolus Herb., ii, 64, pl. v, fig. 17; *Cr. lanceolata* Endl. in Walp. Rep., ii, 254 (ex horto Petrop. in Herb. Kew), appears to be this species of rather lanky growth.

Tetraphyle campestris E. et Z., Enum., No. 1873; *T. lanceolata* E. et Z., *loc. cit.*, No. 1874; *T. muscosa* E. et Z., *loc. cit.*, No. 1872.

Widely spread throughout South Africa in fairly dry localities, absent in the Karroo and Kalahari.

Two South African forms were distinguished by me in the Ann. Bolus Herb., ii, 65. Very similar forms are found all over the world except in the greater part of Asia. A species known in Europe as *Tillaea muscosa* L. in Sp. Pl. (1753), 129, is almost indistinguishable from it, but has no squamae. It was called *Cr. muscosa* by Roth in Enum. Pl. Germ., i (1897), 994. However, Linnaeus' *Cr. muscosa* in Amoen. Acad., 6, and Pl. Afr. Rar., 10, is probably *Cr. lycopodioides* Lam.

Compare my remarks in Ann. Bolus Herb., ii, 64, 65, to which unfortunately I cannot add anything as my notes, based on an examination of numerous specimens from many parts of the world, have been lost, except that Nos. 19 and 20 in Linnaeus' Herb., London, look exactly like *Cr. campestris* E. et Z. They are named *Cr. muscosa*.

25. **Cr. parvula** Endl. in Walp. Rep., ii, 253; Harv. in Fl. Cap., ii, 352; Schonl. in Ann. Bolus Herb., ii, 66, pl. v, fig. 18.

Tetraphyle parvula E. et Z. in Enum., No. 1871.

Southern coast districts from the Cape Peninsula to East London, Murraysburg, Drakensberg, Basutoland in dry pastures.

26. **Cr. transvaaliensis** O. Ktze. in Herb. Berol.; Schonl. in Ann. Bolus Herb., ii, 66, pl. v, fig. 19.

Cr. subulata (Hook.) Harv. (non Linn. nec E. et Z.) in Fl. Cap., 352.

Thisantha subulata Hook. in Ic. Pl. (1843), t. 590.

Tillaea subulata Benth. et Hook. f. in Gen. Pl., i, 658 ; Britten in Oliver, Fl. of Trop. Afr., ii, 367 ; Hiern in Pl. Welwitsch., i, 325.

Eastern parts of Cape Province to Natal (but not near the coast), the Transvaal and East Tropical Africa, Socotra, S.W. Protectorate, Angola.

27. **Cr. bergioides** Harv. in Fl. Cap., ii, 352 ; Schonl. in Ann. Bolus Herb., ii, 67, pl. vi, fig. 20.

Cr. pusilla Schonl. in Rec. Albany Mus., ii (1913), 451.

Malmesbury, Breede River, Worcester ; widely spread from Caledon to Worcester (teste Schlechter).

28. **Cr. aristata** Schonl. in Engl. Bot. Jahrb., xliii (1909), 362, and Ann. Bolus Herb., ii, 68, fig. 14.

Only known from a specimen in Herb. Berol. marked " Crassula, Cap. b. spei, Hort. Berol., Jul. 1846, 199 (46)."

Lycopodioides group.

29. **Cr. lycopodioides** Lam., Encycl., ii, 173 ; DC., Prodr., iii, 385 ; Harv. in Fl. Cap., ii, 351 ; Schonl. in Ann. Bolus Herb., ii, 69, fig. 15, pl. vii, fig. 26 ; Cannon in Vegetation of the more arid regions of South Africa, Washington, 1924, pl. 30, B.

Cr. imbricata (Solander) in Ait. Hort. Kew., i, 393 ; *Cr. littoralis* Endl. in Walp. Rep., ii, 253.

? *Cr. muscosa* L., Sp., 405 (ex DC.), Pl. Afr. Rar., 10 (ex Ind. Kew.).

Cr. muscosa Thunb. in Fl. Cap., ed. Schultes, 281.

Cr. polpodacea Endl. in Walp. Rep., ii, 253 ; *Cr. propinqua* Endl. in Walp. Rep., ii, 253.

Cr. anguina Harv. in Fl. Cap., ii, 350.

Tetraphyle lycopodioides E. et Z. in Enum., No. 1870 ; *T. polpodacea* E. et Z., *loc. cit.*, No. 1869 ; *T. littoralis* E. et Z., *loc. cit.*, No. 1867 ; *T. propinqua* E. et Z., *loc. cit.*, No. 1868.

Widely spread in dry stony localities from Namaqualand to Naauwpoort and along the coast to Komgha.

The varieties instituted by Harvey in the Fl. Cap. cannot be sharply defined. Lamarck's originals at Paris represent a stout form with gemmae with broadly ovate, subacute leaves.

" *Cr. muscosa* " is represented in Thunberg's Herb., Upsala, by two sheets. α has been marked in Thunberg's handwriting " *lycopodioides* Lam." β is $=$*Cr. campestris* (E. et Z.) Harv.

Thunberg's description in Fl. Cap., 281, of *Cr. muscosa* evidently refers to α and not to β.

(*Cr. pseudolycopodioides* Dinter et Schinz in Dinter, Deutsch Südwest Afrika, is not known to me.)

UMBELLATA group.

30. **Cr. Dodii** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 372; Schonl. in Ann. Bolus Herb., ii, 70, fig. 16, pl. vi, fig. 21.

On the hills near Van Rhynsdorp, 300 ft., Schlechter, 10994. Type: Herb. Albany Mus.; Seven Weeks Poort Mt., north side, 6800 ft., Stokoe, 1880 (fls. tetramerous); Sutherland, on mts., Marloth, 10413.

31. **Cr. umbellata** Thunb. in Prodr., 54, Fl. Cap., ed. Schultes, 279; DC., Prodr., iii, 389; Schonl. in Ann. Bolus Herb., ii, 71, pl. vi, fig. 22.

Cr. umbella E. Mey. (ex Harvey); *Cr. alpina* Endl. in Walp. Rep., ii, 253; *Tillaea umbellata* Willd., Sp. Pl., i, 271; *Petrogeton alpinum* E. et Z. in Enum., No. 1858; *Bulliarda alpina* Harv. in Fl. Cap., ii, 330.

On ledges of rock, dry places, and sandy ground on the Cape Peninsula, also in the Malmesbury div., and near Caledon; Redhouse, near Port Elizabeth, Rosenbrock, 499, in Herb. Berol. Type in Herb. Thunberg, Upsala.

Var. *nana* Schonl. in Ann. Bolus Herb., ii, 72.

Cr. nana Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 327.

Zuurfontein, Western Region, c. 150 ft., Schlechter, 8560 (type in Herb. Albany Mus.); top of Chavonnes Mt. (Worcester), moist cliff, 1500 ft., Marloth, 13305.

32. **Cr. Marlothii** Schonl. in Journ. Linn. Soc. (Bot.), xxxi (1897), 553, Ann. Bolus Herb., ii, 72, pl. vi, fig. 23.

On shady rocky places of the Matroosberg, 4500 ft., Marloth, 2202.

This is not identical with *Cr. minima* Thunb. in Prodr., 57, Fl. Cap., ed. Schultes, 292, as I had suggested.

33. **Cr. silvatica** Licht. in Roem. et Schult., Syst., vi, 726; DC., Prodr., iii, 390; Schonl. in Ann. Bolus Herb., ii, 72, pl. vi, fig. 24.

? *Cr. strigosa* Linn., Amoen., vi, 86; DC., Prodr., iii, 389 (non Lam. ?).

Cr. pellucida Thunb. (non Linn.) in Prodr., 54, Fl. Cap., ed. Schultes, 282 (specimens preserved in Herb. Thunberg).

Cr. dichotoma Herb. Jacquin (non Linn.).

Cr. pubescens Endl. in Walp. Rep., ii, 252.

Cr. diaphana litt. A. in coll. Drege.

Cr. Sarcolipes Harv. in Fl. Cap., ii, 355.

Sarcolipes pubescens E. et Z. in Enum., No. 1853.

S.W. Cape Province from Clanwilliam to Mossel Bay, extending inland to the Bokkeveld. Type in Herb. Berlin.

Var. *diaphana* Schonl. Calyx-lobes ½ the length of the petals, whereas in the type they have about the same length.

Cr. diaphana E. Mey.; Harv. in Fl. Cap., ii, 355; Schonl. in Ann. Bolus Herb., ii, 73.

Cr. diaphana litt. B. in coll. Drege in Herb. British Museum.

"Between Nieuwekloof and Slangenkeuwel." In Herb. Berlin there is a specimen collected by Drege named ? *Cr. inanis* (Th. litt. A.) E. Mey. It has nothing to do with *Cr. inanis* Thunb.

CORALLINA group.

34. **Cr. peploides** Harv. in Fl. Cap., ii, 355 ; Schonl. in Ann. Bolus Herb., ii, 74.

Witbergen, 7000–8000 ft., Drege (ex Harvey).

Only known to me from the description.

35. **Cr. corallina** Thunb. in Nova Acta, vi (1778), 329, 332, Prodr., 56, Fl. Cap., ed. Schultes, 290 ; Linn., Syst. Veg., xiv, 306 ; L. f. Suppl., 188 ; Willd., Sp. Pl., i, 1549 ; DC., Prodr., iii, 188 ; Harv. in Fl. Cap., ii, 366 ; Britten and Baker f. in Journ. of Bot., xxxv (1897), 480 ; Schonl. in Ann. Bolus Herb., ii, 74, pl. vii, fig. 25 ; Marloth, Fl. of S. Africa, ii, pl. v, F.

Cr. dasyphylla Harv. in Fl. Cap., ii, 355.

Cr. Simiana Schonl. in Journ. of Linn. Soc. (Bot.), xxxi (1897), 552. Type in Herb. Thunberg, Upsala.

Sandy places from Namaqualand and Bushmanland through the Karroo to the Stormberg and Somerset East.

(*Cr. debilis* Thunb., Fl. Cap., ed. Schultes, 280 (*Purgosea debilis* G. Don, Syst., iii, 104) cannot be identified with certainty from the description, though evidently it belongs to sect. *Tillaeoideae*. It is not represented in Thunberg's Herbarium.

Two other species, namely, *Cr. Dregei* (Harv.) Schonl. (*Bulliardi Dregei* Harv.) and *Cr. cordata* Thunb., were, in Ann. Bolus Herb., ii, 75 and 76, tentatively referred to sect. *Tillaeoideae*. After having seen the types I must remove them. They will be referred to later on.)

SECT. II. STELLATAE Schonl.

PELLUCIDA group.

This includes *Cr. centauroides* and *Cr. brachypetala* of the Fl. Cap., the remaining species placed by Harvey under *Filipedes* have been removed by me to sect. *Tillaeoideae*, though *Cr. expansa* leads up to this group.

Remarks on *Cr. centauroides* L., *Cr. pellucida* L., *Cr. marginalis* Dryand., and *Cr. lineolata* Dryand.

Cr. pellucida L., Sp. Pl., 283 (1753), was founded by the author on a figure and description in Dillenius, Hort. Eltham. (t. 100, f. 119). Original specimens are preserved in Herb. Dillenius, Oxford. It was quite misunderstood by Harvey, who quotes it under his *Cr. Sarcolipes* as of

Thunberg, who started the mistake, as shown by the material in the latter's herbarium at Upsala. Specimens received from Mrs. L. Bolus in 1918 from Table Mountain could be well matched with the figure and description by Dillenius. Other specimens received at the same time could be matched with the figure in Bot. Mag., t. 1765, described as *Cr. centauroides* L., Sp. Pl., 404. There was no essential difference in the flowers between these two, and other specimens showed all gradations between them in the nature of the vegetative organs and the inflorescences. The flowers were the same. Thus *Cr. pellucida* L. and *Cr. centauroides* L. as represented by the Bot. Mag., t. 1765, must be united. Whether t. 1765 really is *Cr. centauroides* L. cannot be decided with certainty, but appears to be likely. If these two species are identical, then, as pointed out by Britten and Baker f. in Journ. of Bot., xxxv, 485, *Cr. pellucida* must take precedence, as *Cr. centauroides* was not published until later (Pl. Rariores Africanae, p. 9, 1760). It may be desirable also to drop the name *C. centauroides* owing to the confusion which has arisen with *Cr. marginalis* and *Cr. lineolata*.

The following notes, based on eighteenth-century herbaria, will show further the confused state of the synonymy :—

a. In Herb. Sherard at Oxford, No. 268, there are specimens named " *Cr. centauroides* L., Sp. Pl., 404, 5, by Sibthorp. They bear two labels.

1. " Sedum Africanum muscosum minimum."
2. " Ficoides Africana annua centauroides Herm. Bat., Raj. Hist., iii, 366 ?." " Sedum minimum Africanum album lanceatis foliis fere umbellatum Pluk. Alm., 348."

They have the aspect of loose specimens of *Cr. glomerata*, with leaves somewhat like those of *Cr. expansa* but more acute. The stem and its branches are scabrid. Identification is hardly possible as the flowers are not suitable for dissection, but the specimens can in any case not be referred to the composite species which Harvey called *Cr. centauroides*.

(There is in this Herb. also the type of *Cr. pellucida* L.)

b. In the Linnean Herb. London :

No. 11 is named " *Cr. centauroides* " in Linn. f.'s handwriting, and on back of sheet in Dahl's handwriting " *Cr. pellucida*." This is *Cr. lineolata*.

No. 12, " *Cr. dichotoma*." This is *Grammanthes gentianoides*.

No. 13, " *Cr. dichotoma*." Allied to and perhaps a form of *Cr. lineolata*.

No. 14, " *Cr. aethiopica*," but this name is crossed out (by Linn. f. ?) and " *dichotoma* " substituted. This is *Cr. pellucida* L.

No. 15, " *Cr. dichotoma*." This is also a scrap of *Cr. pellucida* L.

c. In Thunberg's Herb. at Upsala :

"*Cr. dichotoma* L. f., Suppl., 188" (Thunb., Prodr., 56, Fl. Cap., ed. Schultes, 286). This is *Cr. pellucida* L. (a form with somewhat narrow leaves).

"*Cr. centauroides* L.," Thunb., Prodr., 56, Fl. Cap., 286. Sheets *α* and *β* are *Cr. lineolata* Soland., sheet *δ* is *Cr. marginalis* Soland.

"*Cr. marginata* Thunb.," Prodr., 56, Fl. Cap., ed. Schultes, 297. This is not *Cr. marginalis* Soland, but *Cr. pellucida* L.

"*Cr. pellucida* L.," Thunb., Prodr., 54, Fl. Cap., ed. Schultes, 282. This is *Cr. silvatica* Licht.=*Cr. Sarcolipes* Harv.

I think I can always distinguish *Cr. pellucida* L., *Cr. marginalis* Soland., and *Cr. lineolata* Soland. I have added full descriptions of them. However, all three vary, especially the last one, and of course it is a matter of opinion whether the varieties which I have distinguished should not be separated as species, but I must confess that I failed to separate them satisfactorily.

According to my view the following, of which I have seen the types and which have been described as separate species, should be united to *Cr. lineolata* : *Cr. brachypetala* E. Mey., *Cr. alsinoides* (Hook. f.) Engl., *Cr. Dregei* Schonl. (*Bulliarda Dregei* Harv.), *Cr. diabolica* N. E. Br., *Cr. Thorncroftii* Burtt-Davy.

36. **Cr. pellucida** L., Sp. Pl., 283 (1753) ; Dillenius, Hort. Eltham., t. 100, fig. 110 ; ? *Cr. centauroides* L., in Pl. Rariores Africanae, 9 (1760) ; *Cr. centauroides* Harv. (p. pte.) in Fl. Cap., ii, 354, Britten and Baker f. in Journ. of Bot., xxxv, 485 ; *Cr. portulacaria* N. L. Burm., Prodr., 8 ; *Cr. marginata* Thunb. in Prodr., 56, Fl. Cap., ed. Schultes, 287 ; *Cr. dichotoma* L. f., Suppl., 188.

Herba perennis glaberrima carnosula parce ramosa ramis prostratis apice adscendentibus. Caulis pellucidus, teres pallide roseus ad nodos inferiores radicans internodiis inferioribus elongatis superioribus brevioribus ultimis brevissimis, inferne efoliatus. Folia subplana carnosula ovato-spatulata acuta vel subacuta basi connata margine saepius leviter crenulata vel denticulata. Inflorescentia terminalis cymosa congesta vel laxiflora basi dichasialis superne saepius subumbellata. Bracteae inferiores foliis similibus, superiores minores ovatae saepius breviter cuspidatae. Flores pedicellati, pedicellis filiformibus inferioribus elongatis superioribus brevibus. Sepala basi connata lanceolata acuta dorso valde convexa. Petala patentia sublibera alba apice pallide rosea deinde coeruleo-purpurea ovato-lanceolata acuta. Stamina quam petala breviora filamentis tenuibus subulatis antheris late ovatis pallide luteis. Carpidia alba basi leviter connata

ovariis oblique oblongo-ovatis stilis subulatis. Squamae albae minutae latiores quam longae apice leviter rotundatae et emarginatae.

Internodia inferiora usque ad 4 cm. longa. Folia c. 2·5 cm. longa. Sepala 5–6·5 mm. longa. Petala 6·5–8 mm. longa. Stamina c. 5 mm. longa. Ovaria c. 4 mm. longa. Stili c. 1·5 mm. longi.

Type in Herb. Sherard, Oxford; Herb. Linnaeus, London (sub *Cr. dichotoma*); Herb. Thunberg, Upsala (sub *Cr. dichotoma*, L. f., Suppl., 188), et *Cr. marginata* Thunb.

Described from live specimens collected on the slopes of Table Mountain by Mrs. F. Bolus, Jan. '18. The species varies considerably in the size of the leaves and even in their shape. They are sometimes quite obtuse. This was the case, *e.g.*, in specimens received from Dr. Marloth in 1893, which, moreover, had a subcapitate inflorescence. The flowers usually vary in size on the same specimen, the youngest being the smallest.

In damp, grassy places near Constantia, 200 ft., MacOwan, 1849; various places on the mountains of the Cape Peninsula: E. and Z.; Un. It., 206; Bergius (under *Cr. retroflexa* and *Cr. marginalis* in Herb. Berlin); Mund et Maire (Kirstenbosch); Scott-Elliot, 96; E. and Z. 1893; Frenchhoek, c. 4000 ft., Schlechter, 9269; George, Bolus, 2631. Kl. Zwartebergen on south side, 6500 ft., Stokoe, 1906 (a dwarf form, creeping, branches c. 4 cm. long, leaves under 6 mm. long). Specimens collected by Schlechter (5876, Silver River, 300 ft.) may belong here or may represent a distinct species.

37. **Cr. marginalis** Soland. in Ait. Hort. Kew., 396, No. 25; Jacquin, Hort. Schoenbrunn., t. 471; *Cr. profusa* Hook. f., Bot. Mag., t. 6044; *Cr. centauroides* Harv. (p. pte.) in Fl. Cap., ii, 354; Britten and Baker f. in Journ. of Bot., xxxv, 483. This is represented in Jacquin's Herb., Vienna, and in Thunberg's Herb., Upsala. In the latter it is named *Cr. centauroides* L., fol. γ.

Herba perennis glaberrima carnosula laxe ramosa prostrata ad nodos distantes radicans. Caulis ramique teretes internodiis quam folia brevioribus vel longioribus, ramis floriferis adscendentibus. Folia subplana infra convexula sessilia connata vel perfoliata patentia orbiculari-cordata obtusa vel acuta vel breviter cuspidata, margine saepius linea rubra circumcincta, intra marginem punctis uniseriatis conspicuis ornata. Inflorescentiae terminales vel ex axillis foliorum superiorum laterales, pedunculatae cymosae capitatae, subumbellatae vel rarius thyrsoideae, bracteis quam folia multo brevioribus, superioribus lanceolatis. Sepala dorso convexa lineari-lanceolata subacuta basi breviter connata. Petala alba vel rubro-tincta ovato-lanceolata subacuminata patentia sublibera. Stamina quam petala breviora, filamentis albis subulatis, antheris ovatis albis. Carpidia alba, ovariis oblique ovoideis, stilis subulatis erecto-patentibus. Squamae albae

minutae latiores quam longae apice rotundatae et leviter emarginatae. Caulis diam. 1·5 mm. Internodia 1–1·8 cm. longa. Folia 1–1·8 cm. longa, 8 mm.–1·6 cm. lata. Bracteae inferiores quam folia saepius dimidium breviora, superiores 2–5 mm. longae. Sepala c. 2·8 mm. longa. Petala c. 5·5 mm. longa. Stamina et carpidia c. 3·6 mm. longa. Stili ovariis subaequilongis.

Herb. British Museum; on the top of Table Mountain (*Cr. minima* E. and Z. (non Thunb.), slopes of the Winterhoeksberg, near Tulbagh, E. and Z. 1895; George, Bolus, 2635; Bitou River near bridge, alt. 10 ft., Fourcade, 1493; shady places in bush near the Zoutpanshoogde, Z. 2526; Redhouse, Oct., Mrs. T. V. Paterson; Kamaehs, near Uitenhage, Nov., Mrs. T. V. Paterson, 381*c*; Bethelsdorp, Paterson, 381; between the Bushmans River and De Begha, Alexandria div., Bennie; Howieson's Poort and near the Quarry opposite the Chronic Sick Hospital, Grahamstown; Drege sine no. et loco (*Cr. centauroides* L. aa).

I have sometimes observed hexamerous flowers in this species. These are common in this section of *Crassula*, but in one of them I found only four carpels, in another only two. Such a reduction in the gynaeceum is very rare in *Crassulaceae*. This species grows in somewhat drier localities than *Cr. lineolata*.

38. **Cr. lineolata** Dryand. in Ait. Hort. Kew., i, 391, No. 81, Britten and Baker f. in Journ. of Bot., xxxv, 483; *Cr. centauroides* Harv. (p. pte.) in Fl. Cap., ii, 354; *Cr. centauroides* Thunb., p. pte.

Herba perennis prostrata ramis adscendentibus. Caulis teres albus internodiis elongatis foliis aequilongis vel longioribus. Folia sessilia connata basi pilosa carnosula subplana cordato-ovata acuta vel cuspidata linea alba cincta, ad margines minutissime papillosa faciebus albo-lineatis (in sicco saepius brunneo-lineatis). Inflorescentia multiflora terminalis saepius breviter pedunculata subcapitata vel cymoso-umbellata, bracteis quam folia multo minoribus. Sepala sublibera ovato-lanceolata acuminata vel acuta dorso carinata viridia rufo-cincta. Petala oblongo-ovata acuta subnavicularia alba vel rubro-tincta. Stamina quam petala breviora filamentis gracilibus teretibus albis antheris oblongis luteo-albis. Carpidia staminis subaequilongis, ovariis oblique ovatis stilis subulatis erecto-patentibus ovariis subaequilongis. Squamae minutae luteo-virides latiores quam longae apice rotundatae et leviter emarginatae. Caulis c. 1 mm. diam. Rami floriferi c. 10 cm. longi. Internodia 1·5–1·8 cm. longa. Folia c. 1·5 cm. longa, 8 mm. lata. Sepala 3 mm., petala 4·5 mm., stamina et carpidia 3 mm. longa.

Herb. British Museum; No. 11 in Herb. Linnaeus (named *Cr. centauroides* by Linn. f. and *Cr. pellucida* by Dahl); *Cr. centauroides*, fol. α and β in Herb. Thunberg.

This is a very variable species.

The above description was drawn up from specimens collected by Mrs. T. V. Paterson in the Baakens River Valley, Port Elizabeth (No. 387*b*), and agreed with Paterson, 381 (Bethelsdorp, Nov.), and Ecklon and Zeyher, 981 (*Cr. marginalis* E. et Z. (non Soland.), "in nemorosis ad Zwartkops River, Nov." I propose to call this var. *typica* Schonl.. to which the following also may be referred: Along roadside to E. Head, Knysna, Jan., Williamson, 121; Port Elizabeth, Nov., I. L. Drege, 630; common in damp kloofs near Grahamstown; Trapps Valley, Dec., Daly, 554 (branches somewhat thicker and internodes in some specimens longer than in the type); Dixon's Bush, Lower Albany, Oct., Bennie, 383; Port Alfred, Britten, 845, Potts, 240, Galpin; Line Drift, Peddie district, Aug., Sim (more robust and with larger flowers than the type); East London, Apr., Rattray, 13; sea-coast near East London, 20–50 ft., Hilner, 239, Galpin, 1863; grassy valleys near Komgha, 2000 ft., Dec., Flanagan, 1079; Himeville, Natal, Jan., Bews, 2 (sepals nearly as long as stamens); *ibid.*, Bews, 3 (sepals slightly exceeding the petals in length).

Several of the specimens enumerated have a few pairs of leaves in which the individual leaves are contracted at the base. This leads to others in which the leaves are distinctly petiolate and which may be classed as a distinct variety.

Var. *petiolata* Schonl.

Here we may distinguish several forms:

(*a*) *forma magna*, flowering branches up to 50 cm. long, with flowering side-branches near the apex, internodes up to 4 cm. long, lines on leaves small and not conspicuous.

In damp shady places near Grahamstown, MacOwan, 299.

(*b*) *forma gracilis* Schonl. (*Cr. elongata* Schonl. in Journ. Linn. Soc. (Bot.), xxxi, 552), usually much more branched than the type with smaller leaves, few-flowered inflorescences, and often longer pedicels, lines on the leaves often absent, the relative length of sepals and petals varies considerably.

To this form *Cr. Dregei* Schonl. in Ann. Bolus Herb., ii, 73 (*Bulliarda Dregei* Harv. in Fl. Cap., ii, 330), must be referred. The originals collected by Drege, both in the Oxford and Kew Herb., have pentamerous flowers in addition to tetramerous ones. It is not *Cr. prostrata* Thunb. (quoted by Harvey as *Cr. prostrata* E. Mey.), as stated on Drege's labels.

Slopes near Zuurberg Sanatorium, 2100 ft., Apr., Schonland, 3245; common in shady places near Grahamstown; old Katberg Pass, 5200 ft., Apr., Galpin, 2392; Cathcart, Mar., Hart, 7; Woodvale, forest under shade of trees, Gwatwyn, Queenstown district, 4000 ft., Mar., Galpin, 2021; summit of Potriverberg, district Maclear, 6450 ft., Mar., Galpin, 6620; Port S. Johns, Jan., Schonland; Pondoland, Bachmann, 532.

(*c*) forma *natalensis* Schonl., much more branched than the type, and leaves usually larger, often without lines, pedicels filiform up to 2·4 cm. long or short (Evans, 641).

Ingolweni, May, Wood, 3054; Ulundi, 5000–6000 ft., June, Evans, 641.

In all those hitherto dealt with, we find the basal region of the leaves, where the two opposite leaves join, distinctly pilose [in dried specimens the hairs may drop off!], a character which, though slight, always distinguishes *Cr. lineolata* from *Cr. pellucida* and *Cr. marginalis*. There are forms in which the hairiness extends to the stem in two lines below the leaves and in others to the pedicels and other parts as well. These I unite in the following variety, which would include *Cr. brachypetala* E. Mey. The length of the sepals varies considerably in this variety as in the previous one. The leaves are sometimes not lineate, either glabrous or pubescent.

Var. *pilosa* Schonl.

Zuurberg, Apr., Paterson, 14; Bedford, Apr., Nicol, 93 (in these specimens which I described as *Cr. brachypetala* E. Mey., var. *parvisepala* in Rec. Albany Mus., i, 116, I found the ovaries minutely serrulate along the dorsal median line and the petals very minutely apiculate, the petals had a minute green stripe from the apex down to about the middle); Flats near Brownlee Station, Kingwilliamstown, alt. c. 1500 ft., Apr., Sim, 1200; Dohne Hill, c. 5000 ft., Mar., Sim, 1201; Mount Coke, c. 2000 ft., Oct., Sim, 1416; along streams and amongst coarse vegetation in valleys, Kentani, Pegler, 474; trailing over rocks, Mar., Cala, c. 4000 ft., Pegler, 1529; at the edge of forests, near Bazija, Tembuland, Baur, 774; near Cedarville, May, Bandert, 176; damp places near Mooi River, 3000–4000 ft., Feb., Wood, 5321; Ngoya Forest, Zululand, Sept., Sim; Mont aux Sources, 6000 ft., Feb., McLean and Bayer, 6; Zwartkops, Natal, 960, and Mooi River station, O. Kuntze; Majuba, Rogers, 126 (p. pte.); Harrismith, Grey Univ. Coll. Herb., 1425 (in the two last ones the leaves are sessile or subsessile). Drege, 6889*c*, labelled "*Cr. brachypetala*" in Herb. Kew, has glabrous leaves and stem, but otherwise agrees with another specimen bearing the original label "*Crassula brachypetala* E. Mey." Both have lineate leaves, but the former should be placed under the type. However, all this shows that no strict separation is possible.

Cr. alsinoides (Hook. f.) Engl. in Abh. Preuss. Ak. d. Wiss., 1891, ii, 1892, 231; *Tillaea alsinoides* in Journ. Linn. Soc., vii, 192; Britten in Oliver, Fl. of Trop. Afr., ii, 387. This was known only from Tropical Africa until Burtt-Davy quoted Rogers, 21414, as belonging to it, in Flowering Plants and Ferns of the Transvaal and Swaziland (1925), 141.

I agree with the determination, but I would place it without hesitation with *Cr. lineolata* var. *petiolata*. It is not even sharply distinguished from forma *natalensis*. The flowers are, however, often solitary.

The following in Herb. Kew cannot be separated from it: Moss and Rogers, 400, The Downs, Pietersburg district; Rehmaan, 6369, Houtbosch; Wood, 4566 (=1105), in bush near Umkomaas, 4000–5000 ft; Gerrard, 1477, Natal.

Cr. Thorncroftii Burtt-Davy, *loc. cit.*, 39, 141 (Reimers Creek, 3500 ft., Thorncroft, 1084) must also be placed here.

Cr. diabolica N. E. Br. in Burtt-Davy, *loc. cit.*, 38, 141, belongs also to this neighbourhood and cannot be sharply distinguished. It is supposed to have a tuberous rhizome, but the tubers borne by Wilms, 521, in Herb. Kew (from near Spitzkop, Transvaal) appear to me to be pathological structures and not normal tubers.

39. **Cr. tenuicaulis** Schonl. in Bull. de l'herb. Boiss., v (1897), 864. Van Reenen, 5500 ft., Mar., Schlechter, 6964.

40. **Cr. Woodii** Schonl. in Bull. de l'herb. Boiss., v (1897), 863. Near Karkloof, Natal, 2000–3000 ft., Apr., Wood, 4485.

41. **Cr. Tysoni** Schonl. in Journ. of Bot. (1902), 289. Rocky places near Kokstad, 5000 ft., Feb., Tyson, 1342.

42. **Cr. involucrata** Schonl. in Bull. de l'herb. Boiss., v (1897), 863. Insiswa Mountains, 6000 ft., Jan., Schlechter, 6448.

Perhaps only a form of *Cr. lineolata*. Like this it has lineate markings of the leaves, and the basal portions of the leaves are pilose.

SPATULATA group (*Petiolares* p. ptc. in Fl. Cap., ii, 334).

43. **Cr. spatulata** Thunb. in Nova Acta Nat. Cur., vi (1778), 330; Prodr., 58, Fl. Cap., ed. Schultes, 293; Ait. Hort. Kew., i, 395; Willd., Sp. Pl., i, 1553; Lam., Dict., No. 116; DC., Pl. Gr., t. 49, Prodr., iii, 386; Haw., Syn. Pl. Succ., 55; E. and Z., Enum., No. 1899; Harv. in Fl. Cap., ii, 348.

Cr. lucida Lam., Dict., ii, 173 (1786).

Cr. cordata Lodd., Cab., t. 359.

Type in Herb. Thunberg; Herb. Lamarck (*Cr. lucida*).

Geelhoutboom, Humansdorp division, 200 ft., Mar., Fourcade, 2117; Humansdorp, Christy, 2; Graaf Reinet Road, near Uitenhage, Kensit, 1; shrubby places near the Zwartkops River, Jan. to June, E. and Z. 1899, Z. 2529; Boschberg, 3500 ft., Jan., Bolus, 1810; Grahamstown, common in open bush, many collectors; Bedford, Vaughan, 72; on the old road through Red Hill Forest, Keiskama Hoek, occasionally scandent, but usually trailing down sunny banks, not common, Stayner, 94; Kingwilliamstown, 1500 ft., July, Tyson, 1002; East London, 20–50, Galpin, 1866, Rattray, 26, Gane, 317; climbing in woods, Prospect Farm, Komgha, Jan., Flanagan, 544.

44. **Cr. cyclophylla** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 363.

Perie, bush near Kingwilliamstown, Schonland, 847.

The suborbiculate shortly petiolate leaves with serrate margin distinguishes this species from its allies.

45. **Cr. latispatulata** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 364.

Zuurberg, Natal, 3000 ft., Wood, 457; Isingolweni, Wood, 3054; ? Ngada Forest, Tsolo district, along streams (specimens without flowers).

46. **Cr. Wyliei** Schonl. in Rec. Albany Mus., ii (1913), 456.

N'Kandhla, Zululand, J. Wylie, 21.3.1903, in Natal Government Herbarium, 13025; J. M. Wood, 8830.

A very distinct species allied to *Cr. latispatulata* Schonl. et Bak. f.

The spathulate sepals are particularly characteristic. As in allied species hexamerous flowers occur.

47. **Cr. inandensis** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 364.

Inanda, Natal, Dec., Wood, 764; *ibid.*, June, Wood, 597.

Wood, 597, was not available when the original description was drawn. I have no doubt it has to be placed here. Its leaves are, however, pubescent and the petals are 5·5 mm. long.

48. **Cr. sarmentosa** Harv. in Fl. Cap., ii, 348; *Cr. ovata* E. Mey. MS. (ex Harvey).

Inanda, Natal, 1800 ft., Wood, 554, 10941; Inchanga, Sim; Owen's Spruit, Umgeni Valley, near Hilton College, Bews.

The following notes, supplementing the description in the Fl. Cap., were made from Bews' specimens:—

Stem terete, slightly swollen at the nodes, reddish with innumerable whitish elongated spots. Leaves flat, slightly succulent, green or slightly tinged with red, especially the teeth. Peduncles and pedicels terete, reddish. Floral bracts small, lanceolate. Petals white or tinged more or less with red. Sepals narrowly lanceolate, slightly convex on back, almost free, about $\frac{1}{4}$ length of petals, red or green. Petals lanceolate, acute, without apical mucro. Stamens very minutely puberulous. Stile very minutely puberulous. Squamae very small, thickish, rounded and slightly emarginate at top.

LACTEA group.

49. **Cr. lactea** Soland. in Ait. Hort. Kew., i, 496; Thunb., Fl. Cap., ed. Schultes, 289; De Candolle, Pl. Gr., t. 37; Sm., Exot., t. 33; Bot. Mag., t. 1771; Jacq., Hort. Schoenbr., t. 430; Harv. in Fl. Cap., ii, 337. Herb. Lamarck; Herb. Thunberg.

Sand dunes, east of mouth of Keurbooms River, 50 ft., May, Fourcade, 232 (Fourcade states that the flowers are blue. This, I venture to think,

is a slip); Van Staadens Mountain, MacOwan; Addo and shady places at Zoutpanshoogde on the banks of the Zwartkops River, May, Z. 311, 2540, E. and Z. 1877; Alicedale, June, Cruden, 259; rocky places near Grahamstown, MacOwan, 613, and other collectors (in flower in July); Port Alfred, Salisbury, 135; East London, 20–50 ft., June, Galpin, 1865; Komgha, 2000 ft., July, Flanagan, 1273; ? Wood, 597, Inanda, Natal (in Herb. Kew).

Harvey thinks that *Cr. argentea* Thunb. in Prodr., 56, and Fl. Cap., ed. Schultes, 289, is this species, but in Herb. Thunb. this is =*portulacea* Lam.

It is a pity Harvey placed this species next to *Cr. arborescens* Willd., and thus separated the latter from *Cr. portulacea*.—*Cr. lactea* usually hangs down from rocks, but under cultivation it often assumes an upright habit. The flowers are usually white, but may assume a reddish tint.

50. **Cr. multicava** Lem. et Verschoff. in Illustr. Hort., ix (1861), Misc., 40; *Cr. quadrifida* Bak. in Saund. Ref. Bot., t. 398; Trelease in Fifth Ann. Rep. Missouri Bot. Gardens, 157, t. 28; Wood, Natal Plants, vol. iv, part 2, t. 326.

Redhouse, Sept., Paterson, 19; in woods between Grahamstown and Bathurst, 1500 ft., MacOwan; Port Alfred, Schonland, 746; sea-coast, East London, 20–50 ft., June, Galpin, 1864; Nahoon River, Gane, 318; in woods near Keimouth, 200 ft., July, Flanagan, 161; Inanda, 1800 ft., June, Wood, 597*b*; Upper Umkomaas (teste Wood). This species spreads very rapidly in Grahamstown gardens, as it develops plenty of brood-buds in the flowering region. The flowers are occasionally tetramerous. The petals are reddish or white (Galpin, Wood). The plant favours slight shade.

51. **Cr. Sladeni** Schonl. in Ann. S.A. Mus., ix (1912), 46.

Little Namaqualand–Richtersveld, low granite hills near Numees mine, Pearson, 6126; common between Kaboos and Sendling's Drift (teste Pearson).

This species is closely allied to *Cr. lactea*. Its leaves are obtuse, sepals are 2 mm. long, their lobes 1·5 mm. The petals are ligulate, obtuse, erecto-patent (thus leading up to the next section), without mucro, 4 mm. long, white with a median dark-red stripe near the apex and irregularly spotted at the apex.

52. **Cr. lignosa** Burtt-Davy in Flowering Plants and Ferns of the Transvaal and Swaziland (1926), 38.

Graskop, Lydenburg district, Rogers, 23594.

According to the author this is allied to *Cr. lactea*, which I doubt very much. The type in Herb. Kew is very fragmentary. The stem is minutely scaberulous. The leaves are distinct at the base, sessile, amplexicaul, broad, flat, glabrous, ovate or ovate-lanceolate, acute, with entire or serrulate margin, c. 2·5 cm. long. The sepals have a subapical dorsal " gland." The flowers are immature and not described in detail. Its affinities are probably

with *Cr. rubicunda* E. Mey., but it seems quite distinct from any other described species.

ARBORESCENS group.

The two species placed under this group, though variable in the shape and size of the flowers and in the size of the leaves, are easily distinguished when alive, though with dried specimens this is sometimes difficult. The distinctions used by Harvey (Fl. Cap., ii, 232) do not hold good. The flowers are white or rosy in both of them, Hexamerous flowers are common.

53. **Cr. arborescens** (Mill.) Willd., Sp., i, 1554; Harv. in Fl. Cap., ii, 337; Marloth, Flora of S. Africa, ii, pl. 6; *Cr. Cotyledon* Jacq. in Misc., ii, 295; Curt., Bot. Mag., t. 384; *Cr. cotyledonifolia* Salisb., Prodr., 309; ? *Cr. arborea*, Med. Beob. (1783), 304; *Cr. punctata*, Hort., Paris (teste Herb. Lamarck).

Cotyledon arborescens Mill., Dict., ed. 8, No. 7.

Perhaps Jacquin's name should have priority.

Laingsburg; Pearston; Oudtshoorn, Aug., Rogers, 3117; Cradock; rocks, mountain-tops near Queenstown, 4000 ft., Aug., Galpin, 1533; Cathcart, Wickens, 1580; Kingwilliamstown.—I doubt whether it grows near the Zwartkops River, as stated in the Fl. Cap. Its leaves are roundish obovate, frequently cuneate at the base, more distinctly punctate than in *Cr. argentea* Thunb., covered with a waxy bloom which is absent in the latter, frequently with a reddish margin when found wild or cultivated in South Africa. The leaves are usually much smaller than when cultivated in European greenhouses. The flowers are usually somewhat larger than in *Cr. argentea*.

54. **Cr. argentea** Thunb. in Nova Acta Nat. Cur. (1778), 329, 337, Prodr., 36, Fl. Cap., ed. Schultes, 289.

Cr. portulacea Lam., Dict., 2, 172; DC., Pl. Gr., t. 79; Harv. in Fl. Cap., ii, 337; Marloth, Das Kapland, pl. 14 and 16, B; *Cr. obliqua* Soland. in Ait. Hort. Kew., i, 393; ? *Cr. atropurpurea* D. Dietr. in Syn. Pl., ii, 1031; *Cr. articulata* Zucc. in Roem. Collect., 136; *Cr. nitida* Schonl. in Rec. Albany Mus., i, 54; *Cotyledon ovata* Mill., Dict., ed. 8, No. 8; *Cr. cotyledoniformis* Lourr. (teste Herb. Lamarck). Type in Herb. Thunberg; Herb. Lamarck (*Cr. portulacea*).

Garies, Namaqualand, Capoon, 900/15; Graaff Reinet, Rattray; Biesjesfontein, Somerset East, 2500 ft., July, MacOwan, 567; Redhouse, Aug., Paterson, 20; Cradock Place, near Port Elizabeth, 100 ft., May, Galpin, 6462; common in the Addo and Fish River bush; Port Alfred, July, Salisbury, 105; on mountain-tops and in karroid scrub near Grahamstown; Nahoon River, East London, July, Gane, 316; krantzes along the

Chichaba River, 1000 ft., Aug., Flanagan, 839 ; Natal, in Natal Gov. Herb., 3584.

It is always an important constituent of karroid scrub, sometimes almost dominant. I place here also a specimen collected by Dr. Pole Evans at Inchanga (Natal) in May 1916. The only difference from the type I can see is that the pedicels are longer and consequently the inflorescence is rather loose, but this is also the case in the specimen figured by de Candolle, Pl. Gr., t. 79.

(A specimen from Saldanha Bay, Trewlaney, 2849/14, probably represents an allied new species, but is too incomplete for description.)

CORDATA group.

Small succulent shrublets with glaucous soft leaves. Of the two species here placed, *Cr. cordata* Thunb. was associated by Harvey with *Cr. spatulata* and *Cr. sarmentosa* in the *Petiolares* group. This grouping is, however, to my mind somewhat artificial. I think the species here united are more nearly allied to *Cr. nemorosa* Endl. on the one hand and *Cr. multicava* Lem. on the other.

55. **Cr. cordata** Thunb. in Nova Acta Nat. Cur. (1778), 328, 330, Prodr., 57, Fl. Cap., ed. Schultes, 293 ; Soland. in Ait. Hort. Kew., i (1789), 396 ; DC., Pl. Gr., t. 121, Prodr., iii, 386 ; Jacq., Hort. Schoenbr., t. 431 ; Willd., Sp. Pl., i, 1553 ; E. et Z. in Enum., 297 ; Harv. in Fl. Cap., ii, 347 ; *Cr. neglecta* Roem. et Schult., Syst., vi, 722 ; *Cr. Aitoni* Britt. et Bak. f. in Journ. of Bot., xxxv (1897), 480 ; *Cr. perfossa* E. Mey. in Herb. Drege.

Herb. Thunberg ; Herb. Lamarck (where reference is made to Pluk., t. 343, fig. 2) ; Herb. Linnaeus, No. 33.

Common in open karroid scrub and on rocky ground ; near the Zwartkops River, E. and Z. 1898 ; Redhouse, Paterson, 153 ; Grahamstown, MacOwan, 561 ; Port Alfred, Salisbury, 129 ; Fish River, 1500 ft., Schlechter, 6106 ; Queens Road, Fish River Valley, 1500 ft., Schonland, 770 ; near quarries, Kingwilliamstown, Galpin, 5956 ; sea-coast, East London, 20–50 ft., Galpin, 1866 (p. pte.).

This species has a very effective mode of propagation by the copious production of brood-buds in the floral region after the flowering period is over.

56. **Cr. glauca** Schonl. n. sp.

Perennis herbacea glaberrima caule adscendenti tereti paucifolio. Folia opposita glauca petiolata lamina carnosula mollia late oblongo-suborbicularia apice obtusa basi cuneata vel subcuneata integerrima supra impresso-punctata. Flores in cymas paniculaeformes laxas terminales dipositi, bracteis minutis. Calycis lobi ovati acuti subliberi. Petala patentia alba

lanceolata acuta. Stamina quam petala breviora, antheris late ovatis. Carpidia petalis subaequilonga stilis filiformibus. Squamae minutae.

The flowering stems reach a height of about 10 cm. Internodes 1–1·4 cm. long. Petiole 2·5–12 mm. long. Leaf-blade 1–2 cm. long. Sepals about 2 mm. long. Petals about 3 mm. long.

Natal Herbarium (Garden, 46). Native habitat unknown. The general appearance of this species and especially the leaves are very much as in *Cr. nemorosa*, but it is more closely allied to *Cr. cordata*.

Galpini group.

57. **Cr. Galpini** Schonl. in Journ. Linn. Soc. (Bot.), xxxi (1897), 547.

On the summits of the highest mountains in eastern Cape Province and of the Drakensberg. Type in Herb. Albany Mus.

Gaika's Kop, Hogsback, c. 6000 ft., Jan., Rattray, 98 ; top of Katberg, on damp rocks, 6500 ft., Jan., Dyer, 375 ; on damp rocks, Andriesberg, 6000–6700 ft., Feb., Galpin, 2000 (type) ; marshy places, Majuba Nek, near Sterkspruit, Herschel district, at least 8000 ft., Jan., Hepburn, 211 ; marsh at base of Dodmans Krantz, Barkly East district, c. 8500 ft., Mar., Galpin, 6616 ; Likhoele, Basutoland, Feb., Dieterlen, 1076 ; slope of Qogolosi, Leribe plateau, 7000–8000 ft., Dieterlen, 994 ; Tosing, Basutoland, Ashton ; Cooper, 678, Albert district (in Herb. Kew) ; Mont aux Sources, Herb. Marloth.

Cr. Galpini is a very aberrant species which is not nearly allied to any other species I am acquainted with. It might very well be placed into a section by itself. I have referred to some of its peculiarities when describing it from specimens found by Mr. Galpin on the Andriesberg. Since then I have seen a good deal of material from a number of localities, none of which showed the dimorphism of the leaves of the original specimens (some of the leaves being thinner and with a few serrations at the apex, while the others were subsemiterete and entire).

Sect. III. TUBEROSAE (Sect. *Crenato-lobatae* and *Tuberosae* of Harv. in Fl. Cap., ii, 335).

I have dealt with this section in Ann. Bolus Herb., ii, 87.

58. **Cr. dentata** Thunb. in Prodr., 57, Fl. Cap., ed. Schultes (1823), 293 ; Harv. in Fl. Cap., ii, 356 (including var. *minor* Harv.) ; *Cr. patens* Endl., Harv. in Fl. Cap., ii, 356 ; *Cr. petrogeton* Endl. in Walp. Rep., ii, 252 ; *Petrogeton typicum* E. et Z. in Enum., No. 1854, 291 ; *P. patens* E. et Z. in Enum., No. 1855, 291 ; *P. dentatum* E. et Z. in Enum., No. 1857, 291. The type of *Cr. dentata* Thunb. is preserved in Herb. Thunberg, Upsala.

The type of *Cr. minima* Thunb. (Prodr., 57, Fl. Cap., ed. Schultes, 292) is there also preserved. It was considered by Harvey, in Fl. Cap., ii, 356, to be a small form of *Cr. dentata* Thunb. I agree with this view. Curiously on p. 356 he enumerates *Cr. minima* Thunb. again amongst the species unknown to him.

Widely spread in S.W. Cape Colony at an altitude of about 900 ft. to 3600 ft. (absent from the Cape Peninsula ?).

59. **Cr. Dielsii** Schonl. in Rec. Albany Mus., i (1904), 117.

Cedarberge, Clanwilliam. Type in Herb. Albany Mus.

60. **Cr. nemorosa** Endl. in Walp. Rep., ii, 253; Harv. in Fl. Cap., ii, 356; *Cr. nivalis* (E. et Z.) Harv. in Fl. Cap., ii, 356; *Petrogeton nemorosum* E. et Z. in Enum., No. 1859, 292; *Petrogeton nivale* E. et Z., Enum., No. 1860, 292.

Type, E. and Z. 1859; near the coast from Humansdorp division to Port Alfred and extending inland to Maraisburg, Cookhouse, Albany division, Victoria East division, Winterberg, and Oxton, near Whittlesea.

61. **Cr. confusa** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 366.

Koudeberg (type in Herb. Albany Mus.); Montagu baths, Marloth, 3271.

62. **Cr. Promontorii** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 366; Marloth, Flora of S. Africa, ii, 17, fig. 6.

Cape Peninsula (Wolley Dod, 1624; Galpin, 4017). Type in Herb. Albany Mus.

63. **Cr. loriformis** Schonl. et Bak. f. in Journ. of Bot., xl (1902), 289.

Kloof over Hex River Station. Type in Herb. Albany Mus.

64. **Cr. umbraticola** N. E. Br. in Kew Bull. (1895), 145; Wood, Natal Plants, i, pl. 7; *Cr. crenatifolia* Bak. f. in Bull. de l'herb. Boiss., ser. ii, vi, 712 (1906).

From the Maclear division to Van Reenen at an altitude of 5000–7000 ft. Type in Herb. Kew.

65. **Cr. simulans** Schonl. n. sp.

Herba perennis tuberosa ommino glabro 8–15 cm. alta, tubero 10–12 mm. diam. globoso vel subgloboso radicibus flexuosis filamentosis dense tecto. Caulis gracilis subflexuosus infra folia 3–6 cm. longus. Folia plana, saepius 6, opposita connata, paribus congestis vel separatis, anguste obovata vel oblonga apice obtusa vel attenuata ad margines omnino serrato-crenata vel basin versus integra 1·5–3 cm. longa. Inflorescentia laxe cymoso-paniculata vel cymoso-corymbosa pedunculata, pedunculo nudo, bracteis minutis vel inferioribus foliis similibus sed minoribus et acutis. Flores stellati. Calycis lobi deltoidei 1 mm. longi. Petala albida sublibera oblongo-lanceolata acuta 2–2½ mm. longa. Stamina quam petala breviora c. 1¾ mm. longa, filamentis subulatis gracilibus antheris late ovatis connectivo

angusto. Carpidia c. 1½ mm. longa, ovariis oblique ovatis stilis subulatis c. ½ mm. longis, stigmatis terminalibus parvis. Squamae membranaceae, roseae, anguste obcuneatae apice rotundatae et leviter emarginatae.

Breede River, between Worcester and Robertson, Leipoldt (Bolus Herb., No. 18525). Type in Herb. Albany Mus.

This species is very similar in its vegetative organs to *Cr. Septas* var. *Leipoldtii* Schonl., which Dr. Leipoldt found some years ago at Montagu, but the flowers are quite different and approach those of *Cr. dentata* in structure.

66. **Cr. coerulescens** Schonl. n. sp.

Perennis nana ad 5 cm. alta tuberosa, tubero subterraneo subgloboso vestigiis radicum tecto ad 6 mm. diam. Caulis erectus simplex filamentosus tenuissimus. Folia pauca radicalia vel paribus remotis ovalia vel transverse subreniformia basi contracta utrinque minute papillosa 2–3 mm. longa. Inflorescentia terminalis cymoso-paniculata pauciflora bracteis minutissimis. Flores pedicellati, pedicellis tenuissimis c. 2 mm. longis. Calyx applanatus gamosepalus, lobis variabilibus saepius brevissimis obtusis. Corolla stellata petalis basi connatis ovato-lanceolatis cuspidatis inferne albis superne coerulescentibus c. 1 mm. longis. Stamina ad oram tubi petalorum affixa. Ovaria oblique ovata stilis filamentosis. Squamae minutae, carnosae.

Rocky ledges on hills at Van Wijksdorp, Ladismith division, 1400 ft., Sept., Dr. J. Muir, 3410. Type in Herb. Albany Mus.

This delicate species may be allied to *Cr. Weissii* N. E. Br., but differs greatly in the inflorescence and size of the flowers. The colour of the petals is unique in *S.A. Crassulaceae* and very rarely found in the order generally.

67. **Cr. Septas** Thunb. in Prodr., 57, Fl. Cap., ed. Schultes, 291 ; Harv. in Fl. Cap., ii, 358 ; *Cr. capensis* Baill. in Hist. d. Pl., 312 ; *Cr. globifera* Spreng in Syst., i, 971.

Septas capensis L. in Sp., 489, Amoen., vi, 53 ; Syst. Veg., xiv, 353 ; Lam., Illustr., t. 276 ; Pluk., Alm., 340, fig. 9 ; Marloth, Fl. of S. Africa, ii, pl. 5, C. Type in Herb. Thunberg.

Frequent on hill slopes in S.W. Cape Province from Malmesbury to Caledon, especially on the Cape Peninsula, also on the Cold Bokkeveld, Pearson, 7245.

A very variable plant which should be studied more extensively yet from live specimens. Even the relative length of the calyx and corolla varies. The floral parts are 5–9-merous, usually 7-merous.

Cr. Septas L. var. *Leipoldtii* Schonl.

Herbacea perennis tuberosa glaberrima. Caulis simplex parte subterraneo erecto vel adscendenti basi tuberoso radicis filamentosis ± tecto, supra solum erectus ± elongatus. Folia 4–8, versus apicem caulis aggregata,

saepius recurva, opposita leviter connata, spatulata vel oblanceolata obtusa crenata vel crenato-dentata margine cartilaginea. Inflorescentia terminalis pedunculata subumbellata, umbella involucrata, bracteis anguste linearibus. Flores 8-meri pedicellati, pedicellis tenuibus. Sepala sublibera lineari-lanceolata obtusa. Petala alba 3–5 nervia, quam sepala duplo longiora. Stamina quam petala $\frac{1}{3}$ breviora, filamentis subulatis, antheris late ovatis, connectivo distincto. Carpidia staminibus subaequalia, ovariis oblique oblongis apicem versus gradatim attenuatis, stilis subulatis leviter recurvis, stigmatis minutis capitatis. Squamae minutae subsemiglobosae.

Montagu, July (Leipoldt in Bolus Herbarium, 15954). Type in Herb. Albany Mus.

Subglobose tuber c. 1 cm. in diam. Subterranean stem 1·5–2 cm. long, aerial portion 1–2·2 cm. long. Leaves 8–12 mm. long, the upper smaller than the lower. Peduncle 2–2·4 cm. long. Involucral bracts 2–3 mm. long. Calyx-lobes 3 mm. long. Corolla lobes 6–6·5 mm. long. Stamens about 4 mm. long. Carpels about 3·5 mm. long, styles about 1 mm. long.

I have drawn up this full description of this variety, as it looks very distinct from *Cr. Septas*. The flowers and leaves are smaller than in the type, the latter have also a different shape and the crenations on the margin of the leaves are much smaller and more numerous, but apart from size there is no difference in the floral structure.

68. **Cr. Saxifraga** Harv. in Fl. Cap., ii, 357 ; ?? Bot. Mag., t. 6068 (an exceptionally luxuriant specimen, but floral structure different from type) ; *Cr. Septas* auct. plur., p. pte. ; *Septas globifera* Bot. Mag., t. 1472 (quoted by Harvey under *Cr. Septas* Thunb.).

Widely spread on the hills in the S.W. Coast Region from Clanwilliam to Port Elizabeth (and Albany ?), extending inland to the Hantam Mts., Bokkeveld, Roggeveld (Marloth, 3913), Hex River Mts. (to an altitude of 5000 ft. on the Matroosberg), also at Bruintjeshoogde, near Somerset East ; Riversdale, Rust, 527 ; Oudtshoorn ; Uitvlugt, Humansdorp division, 1200 ft., June, Fourcade, 2618.

This species varies enormously in its vegetative organs, and also to a certain extent in the size and relative length of the floral organs. The absence of bracts at the base of the umbel seems to be a constant character distinguishing this species from *Cr. Septas* in addition to floral characters.

69. **Cr. Bartlettii** Schonl. n. sp.

Herbacea perennis tuberosa glaberrima. Caulis simplex subterraneus carnosus radicibus tenuibus tectus. Folia radicalia rosularia spatulata obtusa subpetiolata integerrima. Inflorescentia terminalis pedunculo gracili aphyllo. Flores pentameri subumbellati pedicellati, pedicellis ebracteosis tenuibus inaequalibus. Calycis tubus brevis, lobi ligulati

obtusi. Petala basi connata alba ovata acuta patentia 3-nervia. Stamina quam petala ¼ minora, filamentis subulatis, antheris late ovatis connectivo distincto. Carpidia staminibus subaequalibus, ovariis oblique ovatiis, stilis suberectis subulatis, stigmatis minutis capitatis. Squamae minutae subhemisphaericae.

Type in Herb. Albany Mus. Near Riversdale, May, H. M. Bartlett in Herb. Muir, 2546 (Dr. Muir notes that the " roots " are tuberous and that the specimen sent is a good average size. I have not seen the tubers).

Underground stem 2·5 cm. long, 4 mm. thick. Leaves (8 in the specimen described) about 2 cm. long (upper obovate portion about equal in length to the lower subpetiolate portion into which it gradually passes). Peduncle about 7 cm. long, about 1 mm. wide. Pedicels 1·5–12 mm. long. Calyx-lobes 1·75 mm. long. Petals 4 mm. long. Stamens nearly 3 mm. long. Carpels about 3 mm. long, the ovaries being slightly longer than the styles, which arise abruptly.

This species is allied to *Cr. Septas.* It has much smaller flowers. The styles in both *Cr. Septas* and *Cr. Saxifraga* pass gradually into the ovary, but in the latter are relatively shorter. The entire, small, subrosulate, subpetiolate leaves of *Cr. Bartlettii* are also characters which separate it from allied species. It comes closest to *Cr. Albertiniae* Schonl., which has crenate leaves and in which the sepals are oblong-lanceolate and unequally bidentate.

70. **Cr. Albertiniae** Schonl. in Ann. Bolus Herb., ii, 93 (1917).

Overwacht, near Albertinia, May, Muir, 1315. Type in Herb. Albany Mus.

71. **Cr. alcicornis** Schonl. in Ann. Bolus Herb., ii, 93 (1917).

Kardouw Pass, Clanwilliam division, Olifants River Mts., July, Mrs. F. Bolus, 14815. Type in Herb. Albany Mus.

72. **Cr. Umbella** Jacq. in Coll., iv, 172, and Ic. Rar., t. 352 ; Tratt, Tab. Pl., 253 ; Harv. in Fl. Cap., ii, 357.

Septas Umbella Haw., Syn., 62 ; *Petrogeton Umbella* E. et Z. in Enum., No. 1856 ; *Cr. flabellifolia* Harv. in Fl. Cap., ii, 357.

Type in Herb. Jacquin, Vienna.

Namaqualand, Clanwilliam, and Sutherland districts. I have pointed out in Ann. Bolus Herb., ii, 91, why I have felt compelled to unite *Cr. flabellifolia* Harv. with this species.

73. **Cr. Weissii** N. E. Br. in Kew Bull., 1908, 434.

Matjesfontein, Weiss, 14. Type in Herb. Kew.

Seems to differ from *Cr. flabellifolia* only by smaller size, and may have to be united with it and consequently with *Cr. Umbella.*

Sect. IV. CAMPANULATAE Schonl.

Acutifolia group

(*Subulares* p. pte. in Fl. Cap., ii, 333; Haw., Syn. Pl., 51; DC., Prodr., iii, 384).

74. **Cr. acutifolia** Lam., Dict., 2, 175, var. *β radicans* Harv. in Fl. Cap., ii, 340); DC., Pl. Gr., t. 2, Prodr., iii, 384; Haw., Syn. Pl. Succ., 52; Harv. in Fl. Cap., ii, 340; *Cr. densifolia* Harv. in Fl. Cap., ii, 340; *Cr. bibracteata* (E. et Z. in Enum., No. 1881, an Haw. ?).

Clanwilliam, Malmesbury, Caledon div., Riversdale, common from the neighbourhood of Port Elizabeth to Komgha, and near Queenstown in dry stony situations, sometimes in the shade of bushes or trees.

Notes supplementary to the description in the Fl. Cap.: Stem terete. Leaves sometimes, when more or less appressed to the stem, concave on the upper side, free or slightly connate, Calyx-lobes not keeled, rounded at the back, about half the length of the petals. Petals white, quite erect or slightly recurved at the apex, oblong ovate, without subapical mucro, $1\frac{1}{2}$–2 mm. (rarely 3) long. Stamens and carpels about $\frac{5}{6}$ the length of the petals. Squamae white, membranous, broadly rectangular, emarginate.

Three varieties may be distinguished.

(*a*) *typica* (*Cr. acutifolia* var. *radicans* Harv. in Fl. Cap., ii, 340). Decumbent, subherbaceous, peduncle often forked below the cyme. This agrees with the type in Herb. Lamarck, Paris, and DC., Pl. Gr., t. 2. It is common near Grahamstown.

(*b*) *Harveyi*. Suffruticose, erect, with much more woody stem and branches. This is considered the type of the species by Harvey, *loc. cit.* It is common in karroid places in the Fish River bush, etc.

(*c*) *densifolia* (*Cr. densifolia* Harv., *loc. cit.*). Erect, subherbaceous, with closely set leaves. Flowers slightly larger than in (*a*) and (*b*). Known to me only from Riversdale (where (*a*) also occurs) and westwards from this locality.

Young flowering specimens of (*b*) cannot be distinguished from (*a*), except that the flowers are slightly larger.

I have examined, amongst others, a large amount of live material from Riversdale collected by the late Mr. H. M. Bartlett and Dr. J. Muir. This has shown me that *Cr. densifolia* Harv. has to be dropped as a separate species (typically represented by Schlechter, 9756 and E. and Z. 1881). There is a specimen in the Berlin Herb. collected in 1820 by Mund and Maire near the Olifants River, named *Cr. biplanata* Haw. It has slightly larger flowers than typical *Cr. acutifolia*, but does not differ otherwise from its frutescent forms. It is evidently identical with Z. 2532 collected near the Zwartkops River, which Harvey quotes under *Cr. acutifolia*. Haworth's

Cr. bibracteata, which Harvey placed under *Cr. densifolia*, is, judging from Haworth's drawing in the Kew Herb., certainly *Cr. acutifolia*. On the other hand, the original drawing of *Cr. biplanata* Haw. at Kew (from plants raised in 1824 from seeds collected by Bowie at the Cape) shows that this does not belong to the neighbourhood. It is perhaps *Cr. fruticulosa* (L. ?) Harv., but the drawing does not admit of exact determination. Haworth himself has suggested that his *Cr. filicaulis* (=*Kalosanthes filicaulis* Haw.) is allied to *Cr. acutifolia*. His original drawing at Kew shows that this has the vegetative organs of *Cr. expansa* and similar but slightly larger flowers than the latter. Floral details are not recognisable.

Cr. ramosa Dryand in Ait. Hort. Kew., ed. 1, i, 390 (non Thunb. nec Harv.), seems to be *Cr. densifolia* Harv., judging from specimens in the British Museum (see Britten et Bak. f. in Journ. of Bot., xxxv, 484). According to Willd., Sp. Pl., p. 1551, *Cr. dichotoma* L. f., Suppl., 188, is =*Cr. ramosa*, but the evidence of the specimens in Linnaeus' Herb. are against this view. Bergius' specimens in the Berlin Herb. labelled *Cr. ramosa* are certainly the form of *Cr. acutifolia* which is =*Cr. densifolia* Harv. I have seen poor specimens of Scott-Elliott, 529, collected on the banks of the Little Fish River and named *Cr. MacOwani*, Scott-Elliott (Journ of Bot., 1891, 69). They belong to *Cr. acutifolia*.

75. **Cr. griquaensis** Schonl. in Bull. de l'herb. Boiss., v, 860.

River bank near Kokstad, Dec., W. Haygarth in Natal Government Herb., 5182, and Wood, 4278, in Herb. Kew.

76. **Cr. rudis** Schonl. et Bak. f. in Journ. of Bot., 1 (1902), 283.

Garies, Alston ; between Stinkfontein and Garies, Pearson, 5645 ; Little Namaqualand, Marloth, 6402.

Very closely allied to *Cr. acutifolia*, from which, amongst other characters, it differs by smaller flowers and squamae which are only slightly emarginate. Type in Herb. Albany Mus.

77. **Cr. tetragona** L., Sp. Pl., 4049, Syst. Veg., 252, Hort. Cliff., 116 ; Fabr., Helmst., 268 ; Thunberg, Prodr., 55, Fl. Cap., ed. Schultes, 283 ; Roy., Lugd., 455 ; Bradley, Succ., v, 18, t. xi, fig. 4 ; Weinmann, Ic., t. 435 (ex DC.) ; Ait. Hort. Kew., i, 391 ; Haw., Syn. Pl. Succ., 51 ; E. et Z. in Enum., No. 1897 ; DC., Pl. Gr., t. 19, Prodr., iii, 384 ; Harv. in Fl. Cap., ii, 339.

Cr. decussata Salisb., Prodr., 309.

Very common in karroid scrub from the Port Elizabeth and Uitenhage division to the Fish River bush, also at Klein Bruintjeshoogde in the Somerset East division ; Somerset Mt. ; Murraysburg ; Graaff Reinet. There is also a specimen in the Bolus Herb. collected by H. Bolus in karroid places near Montagu baths. Herb. Linnaeus, No. 7 ; Herb. Thunberg.

Cr. tetragona is frequently reproduced vegetatively by leaves dropping

and developing adventitious roots and shoots. This species leads up to the "Perfilatae," to which I have removed *Cr. brevifolia* Harv., renamed by me *Cr. Pearsoni.*

78. **Cr. connivens** Schonl. in Rec. Albany Mus., ii (1907), 141.

Type in Herb. Albany Mus.

Liliefontein, Namaqualand, Pearson, 6432 (or 6342 ?); De Doorns, Hex River Valley, c. 1700 ft., Bolus, 13099; Matjesfontein; Prince Albert; ? Hanover, Sim, 15.

This species has very much the appearance of the ligneous, suffruticose forms of *Cr. acutifolia*, but the petals are connivent, and here we meet for the first time, amongst the species dealt with amongst *Campanulatae*, with a subapical mucro on the petals.

79. **Cr. planifolia** Schonl. in Rec. Albany Mus., ii (1907), 142.

Nobemgubo, near Columbo mission, Kentani district, trailing over rocks on dry hills, c. 1000 ft., Sept., Pegler, 1454.

Resembles the larger forms of *Cr. acutifolia* but with almost flat, white, spotted leaves, the squamae are somewhat longer than in *Cr. acutifolia* and not so deeply emarginate.

PERFORATA group (*Perfilatae* Harv. et auct. al. p. pte.).

80. **Cr. perforata** Thunb., Nova Acta Nat. Cur., vi, 1778, 338, Prodr., 56, Fl. Cap., ed. Schultes, 287; Linn. f., Suppl., 190; Willd., Sp. Pl., i, 1550; E. et Z. in Enum., No. 1838; Harv. in Fl. Cap., ii, 338.

Cr. perfossa DC., Pl. Gr., t. 25 (non Lam.); *Cr. Anthurus* E. Mey. in Herb. Drege (perhaps distinct).

Type in Herb. Thunberg.

Riversdale; Montagu baths; Cogmans Kloof, O. Kuntze; rocks near Knysna forest, Marloth, 1880; Kromme River (Humansdorp division); common amongst dry shrub or in rocky places from the Uitenhage division to East London from near sea-level to about 2000 ft., hanging from rocks or scrambling through bushes up to 4 ft. high; also near Queenstown, at an altitude of 3600 ft. (Galpin, 8336); Graaff Reinet; Fields Hill, Natal (Natal Herbarium, Garden, No. 50), and Inanda.—In Herb. Linnaeus, No. 5, was marked *telephoides*! This name is crossed out and "*perfoliata*" substituted. It is further marked "Cap. 644" and "*minima*" H.B. [Herbarium Banks]. However, it is *Cr. perforata* Thunb.

81. **Cr. rupestris** Thunb. in Nova Acta Nat. Cur. (1778), 329, 337; Prodr., 56; Fl. Cap., ed. Schultes, 288.

Cr. perfossa Lam. in Encycl., ii, 173; Jacq., Hort. Schoenbr., t. 432; DC., Prodr., iii, 385; E. et Z., Enum., No. 1889; Harv. in Fl. Cap., ii, 338; Marloth, Fl. of South Africa, p. 21, fig. 12, pl. 5, D, and Das Kapland, pl.

xiv, and p. 225, fig. 85 ; Cannon in Vegetation of the more arid portions of South Africa, pl. xvii, B ; *Cr. perfilata* Scop., Delic. Insub., iii, 12 ; *Cr. punctata* Mill., Gard. Dict., ed. 8, No. 7 ; *Cr. coronata* Heynh., Nom., ii, 162 ; *Cr. connata* Donn., Hort. Cantab., ed. 3, 52 ; *Cr. monticola* N. E. Br. in Gard. Chron., 1882, ii, 264.

Type in Herb. Thunberg ; Herb. Lamarck (*Cr. perfossa*).

Clanwilliam ; rocks, Nieuwekloof, 500 ft., Feb., Schlechter, 7487 ; Tubagh waterfall, Scott-Elliott, 98 ; Table Mt. ; Muizenberg Mt. ; Hex River East ; Knysna division at Noetzie ; Oudtshoorn ; Swanepoelspoort ; Cookhouse ; Bushmans River Station ; Alicedale ; Bothas River Valley, near Grahamstown.

Marloth notes that it is common in the Karroo from Worcester to Laingsburg and Oudtshoorn. Mr. F. H. Holland, who forwarded it from the hills near Swanepoelspoort, wrote that it is a favourite food of horses.

Frequent variations in the shape and size of the vegetative organs occur.

Specimens collected by Mr. Volschenk at the Montagu Pass were dwarf, with leaves about 3 mm. long.

82. **Cr. conjuncta** N. E. Br. in Gard. Chron., 1902, xxxi, 106.

Cr. Patersoniae Schonl. in Trans. Roy. Soc. S.A., i, 446.

Bethelsdorp and Cradock Place, near Port Elizabeth, May, June, Paterson, 664, Galpin, 6460. Type in Herb. Kew ; Herb. Albany Mus. (*Cr. Patersoniae*).

83. **Cr. deltoidea** Thunb. (non auct. al.) in Nova Acta Nat. Cur., vi (1778), 329, 334, Prodr., 56, Fl. Cap., ed. Schultes, 288.

Cr. rhomboidea N. E. Br. in Gard. Chron., 1886, ii, 712.

Matjesfontein ; between Beaufort West and Willowmore ; Uniondale division, near Adamskraal ; Ladismith division ; Baroda, 15 miles north of Cradock.

The beautifully preserved type is in the Thunberg Herb., Upsala, and agrees well with N. E. Brown's type of *Cr. rhomboidea* at Kew.

84. **Cr. Pearsoni** Schonl. in Ann. S.A. Mus., ix (1912), 47.

Cr. brevifolia Harv. in Fl. Cap., ii, 339.

Namaqualand ; Springbokfontein, Springbokkeel, and Lislap, Apr.-May, Z. 661 ; Meyer's bank, June, Max Schlechter, 117 ; Richtersveld, Pearson, 6089 ; Steinkopf, Marloth, 6515.

Type : Z. 661.

A full description drawn up from fresh specimens was given by the writer in Ann. S.A. Mus., ix, 47. It has been found desirable to drop Harvey's most unsuitable name and retain it for the plant described in Fl. Cap., ii, 330, as *Bulliarda brevifolia* E. et Z.

85. **Cr. MacOwaniana** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1899), 361 ; *Cr. ramosa* Harv. in Fl. Cap., ii, 339 (non Ait.).

Namaqualand, Scully, 191 ; Garies, Alston ; between Springbok and O'okiep, Pearson, 5956 ; Langebergen, Plat Klip, on granite, Van Rhynsdorp division, 1500 ft., Oct., Marloth, 13008 (flowers with foetid smell) ; Cogmanskloof, O. Kuntze ; Oudtshoorn, Marloth, 6338.

Var. *crassifolia* Schonl. in Ann. S.A. Mus., ix (1912), 48. Little Namaqualand, granite hill behind Nieuwe Rust, Pearson, 5503.

Both the type and the variety are in the Herb. Albany Mus.

Harveyi group.

(*Cr. fruticulosa* L., Mant., i, 61. This species cannot be satisfactorily ascertained. In Linnaeus' Herb., No. 6 is named by Linnaeus "*Cr. tetragona*," but it cannot be *Cr. tetragona* L., Sp. Pl., 404. It is probably *Cr. caffra* L., Mant., 2nd ed., 222, with the description of which it agrees in a number of important characters. It is, however, certainly the same species, which in Thunberg's herbarium is called *Cr. fruticulosa* (Thunb., Prodr., 55, Fl. Cap., ed. Schultes, 283). I think it is a form of *Cr. Harveyi*. Whether it is the plant which Harvey in Fl. Cap., ii, 340, called *Cr. fruticulosa* L.?, I am unable to say for certain. He based it on broken specimens collected by Zeyher at Uitenhage which I have not seen, but which probably have to be referred to *Cr. Kuhnii* Schonl. De Candolle in Prodr., iii, 354, suggests that *Cr. revolvens* Haw. in Phil. Mag. 1824, 183, is *Cr. fruticulosa* L.

In view of all this uncertainty the following names are better ignored in future : *Cr. fruticulosa* L., *Cr. caffra* L., *Cr. revolvens* Haw.)

86. **Cr. Harveyi** Britt. et Bak. f. in Journ. of Bot., xxxv (1897), 487 ; *Cr. alpestris* Harv. in Fl. Cap., ii, 341 (non Thunb.) ; *Cr. biplanata* E. et Z. in Enum., No. 1880 (an Haw. in Phil. Mag., 1824, 186 ?) ; *Cr. laxa* Schonl. in Journ. Linn. Soc. (Bot.), xxxi, (1897) ; *Cr. basutica* Schonl. in Rec. Albany Mus., ii, 451 ; *Cr. dependens* Bol. in Journ. Linn. Soc. (Bot.), xviii (1881), 391 ; *Cr. montis Moltkei* Dinter in Fedde's Report.

This is a very variable species. As regards its vegetative organs, a number of forms develop a more or less upright main stem and have closely set leaves (which, however, vary in length, from 8–20 mm., and shape). In other forms there is richer branching, the leaves are not closely set and the branches may be decumbent (*Cr. dependens* Bol.). The young stem and branches are frequently more or less pubescent. The flowers vary in size, the petals being in some $2\frac{1}{4}$ mm. long, while in others they reach 5 mm. The variations are to a certain extent due to the conditions under which the plants grow. I have seen this in cultivated specimens which, when developing their vegetative organs luxuriantly, increase also the size of their

flowers. I may add, the length of the peduncle varies considerably in plants from the same locality.

(*a*) *typica* Schonl. A distinct more or less ligneous upright stem developed or main branches upright. Leaves closely set (including *Cr. laxa* and *Cr. basutica*).

Sandy places, mountain sides on the Onderbokkeveld, E. et Z., No. 1880; Rondveld, near Murraysburg, Jan., 6500 ft., Tyson, 365; Boschberg, 4500 ft., MacOwan, 1102 and 1406; Kagaberg, Dec.–Jan., 3200 ft., MacOwan, 1103; Katberg, 5000 ft., Dec., Jan., Dyer, 377; Hogsback, Rattray, 97; Perie, 4000 ft., Dec., Sim, 1206; Windvogelberg, near Cathcart, Sim; Andriesberg, 6700 ft., Feb., Galpin, 2002; between Encgobo and Cala, alongside road, Feb., Pegler, 1523; Bazija, Feb., 2400 ft., Baur, 629, 906; Mt. Currie, Griqualand East, 5500 ft., Feb., Tyson, 1755; Aliwal North, 5000–5500 ft., Feb., Galpin, 2317; Majuba Nek, Herschel district, Jan., Hepburn, 212; W. slopes of Drakensbergen, Hepburn, 293, 294; Bester's Vley, near Witzie's Hoek, O.F.S., Dec., 5500 ft., Flanagan, 1838, Bolus, 8160; Tsitsa footpath, district Maclear, 7480 ft., Mar., Galpin, 6615; Leribe, Basutoland, Dieterlen, 252*b*; Mafeteng, Dieterlen, 548; Mont aux Sources, 9500 ft., Jan., Flanagan, 1823.

(*b*) *intermedia* Schonl. Richly branched, rarely with a distinct ligneous stem, leaves not closely set, narrower than in the type, internodes sometimes as long as leaves; frequently sparingly pilose.

Formosa, Plettenberg Bay, 200 ft., Feb., Fourcade, 2003; Hankey, Feb., Paterson, 27; Hanover; Koolfontein, 9–12 miles S.W. of Burghersdorp; Ugie, Surat, c. 4300 ft., Jan., Britten, 4507; Elandshoek, near Aliwal North, c. 4650 ft., Mar., F. Bolus, 10354; Majuba Nek, Herschel district, Jan., Hepburn, 200 ft.; Maclear; Matatiele; Barkly Pass, 8000 ft., Rattray, 2132; Leribe, Dieterlen, 252*a* (approaches closely the typical form except that the branches are more pubescent); Grants Hill, Bloemfontein, Potts, 2198.

(*c*) *dependens* Schonl. Much branched, branches elongate, slender, without distinct main stems, internode usually about the length of the leaves or slightly shorter, rarely longer (including *Cr. dependens*).

Damp shady places, mountain-side near Graaff Reinet, 3700 ft., Feb., Bolus, 658; in grassy mountain clefts, Koudeveld, Murraysburg, 6500 ft., Jan., Tyson, 365; near Bushmans cave, trailing over rocks, Cala district., c. 4000 ft., Feb., Pegler, 1525; on wet rocks, mountain-side, Queenstown, 4000 ft., Feb.–Mar., Galpin, 2022; S.W. Protectorate (*Cr. montis Moltkei* Dinter, 524).

87. **Cr. Kuhnii** Schonl. in Rec. Albany Mus., i (1904), 114; ? *Cr. fruticulosa* Harv. in Fl. Cap., ii, 340.

Prince Alfred's Pass, 900 ft., Mar., May, Fourcade, 1271, 2055; Kl.

Zwartebergen, N. side, 6000 ft., Andreae, 1277; Cango Valley, Marloth, 12370; Humansdorp, Apr., Pearson, 979/14; Fort Brown, Fish River Valley, Apr., Schonland, 520.

This is perhaps only a robust form with larger flowers of the following species.

88. **Cr. punctulata** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 362.

Mountains beyond Vogelgat, 500 ft., Apr., Schlechter, 10403; Riversdale Mts., Feb., Volschenk, 3; Mossel Bay, Apr., Pearson, 347/14; Matjesfontein, Pearson, 1890/14; Knysna, Pearson, 268/16; Dubbel Bay, Knysna, 1600 ft., Mar., Phillips, 18; Cockscomb, Uitenhage division, Mar., Paterson, 2041.

This is rather inappropriately named and poorly described. The following are notes from live specimens of Volschenk:—

Quite glabrous, perennial, suffruticose, much branched, c. 22 cm. high, older branches and basal portions of younger ones efoliate and subligneous, younger laxly leafy. Branches terete in upper parts, subquadrangular below. Leaves and young branches glauco-pulverulent. Leaves slightly connate, lanceolate, very acute at the apex, slightly incurved, 7-8 mm. long, in transverse section either oval, or flattened above or flattened on both sides. Inflorescence terminal with a few-flowered congested cyme at the apex. Peduncle slender, 3–5 cm. long, bearing a few depauperated pairs of leaves. Floral bracts small, lanceolate. Flowers subsessile or with short pedicels. Sepals lanceolate, obtuse, convex on the back, lobes c. 1·25 mm. long. Petals white, free, erect, recurved at the apex, sublanceolate, c. 5 mm. long. Stamens a little over 4 mm. long; filaments subulate white; anthers small, broadly oblong, brown, pollen yellow. Carpels rather slender, 3·5 mm. long, the ovaries passing gradually into the subulate styles which are about $\frac{1}{3}$ the length of the carpels and are slightly bent inwards. Squamae very minute, fleshy, yellow, broader than long, rounded and slightly emarginate at the apex.

89. **Cr. sarcocaulis** E. et Z. in Enum., No. 1884; Harv. in Fl. Cap., ii, 341.

Roggeveld, Marloth, 3911 (has rather broad calyx-lobes and shorter petals than the type); Graaff Reinet, mountain-tops (teste Harvey); Amatolas; mountain-top, Zwartkei, 5800 ft., Mar. (flowers white, sometimes pink), Galpin, 2642; Silo, E. and Z., No. 1884 (flowers deep pink); summit of Andriesberg, Feb., 6700 ft., Galpin, 2001; ? Majuba Nek, Herschel district, Hepburn, 219 (without flowers); summit of Drakensberg, source of Tina River, Mt. Fletcher district, Mar., c. 8750 ft., Galpin, 6614; ? edge of marsh at base of Doodmans Krantz Mt., Barkley East district, c. 8500 ft., Galpin, 6627 (without flowers); Majuba Hill (Natal),

Mar., Rogers; Charlestown, Natal, 1800 m., Mar., O. Kuntze (stouter and with longer leaves than usual).

This species is closely allied to *Cr. Harveyi* Britt. et Bak. f., but can be easily distinguished by its fleshy stem and the subdichotomous branching. The leaves vary in width and are often oblong lanceolate with strongly reflexed margins. The young stem, pedicels, leaves, and sepals are often more or less covered with somewhat coarse hairs, but I see no justification in separating a var. *scaberula* as Harvey has done in the Fl. Cap. The colour of the flowers is white or pink. In Galpin, 2001, they were crimson on the outside, creamy white inside. The inflorescence is frequently sessile, sometimes shortly pedunculate.

90. **Cr. parvisepala** Schonl. in Journ. Linn. Soc. (Bot.), xxxi (1897).

Saddle Back Mt., Barberton, 4500–5000 ft., July, Galpin, 979; Potgietersrust, amongst rocks, Mar., Galpin, 8976; *ibid.*, 5600–6500 ft., Galpin, 8809; Pilgrims Rest, Mar., Rogers, 14613; Port Shepstone, July, Van der Bijil.

Galpin, 8809, is more luxuriant than the type, with larger leaves and flowers. A live specimen (originally from the Transvaal) received from the National Botanic Gardens, Kirstenbosch, showed the following characters additional to the original description: Leaves oblanceolate acute, fleshy but flat, floral bracts deltoid, petals with a very minute subapical mucro, anthers brown, pollen yellow, squamae yellow. In the original description it is stated "stylis subalatis." This is a misprint. It should be "stilis subulatis." The sepals are sometimes longer than in the type.

91. **Cr. ericoides** Haw. in Phil. Mag. (1825), 30; *Cr. furcata* Endl. in Walp. Ann. Rep., ii, 253; *Tetraphyle furcata* E. et Z. in Enum., No. 1866; Harv. in Fl. Cap., ii, 350.

Hills beyond Stanford, 100 ft., Apr., Schlechter, 10427; Kleinfontein, Mund and Maire, Jan., 1920; Cape Peninsula, Drege, 6903*b*; Swellendam, O. Kuntze; Winterhoek, Z. 2523; Riversdale, Feb., Marloth, 3575, Rust, 63; northern slopes of Knysna Heads (East), 50–200 ft., Schonland, 3392; Woodbourne (Knysna), grassy slopes near lagoon, Jan., Duthie, 880; Noetzie, Knysna division, sourveld of coastal plateau, common, 600 ft., Feb., Keet, 693; Formosa, Plettenberg Bay, 200 ft., Mar., Fourcade, 611; Kareedouw, Humansdorp division, frequent in dry parts, Jan., Britten, 1256; sandy flats, Van Stadens, Zeyher; Aasvogelberg, Drege; common near road from Uitenhage to Van Stadens, about 10 miles from Uitenhage, c. 500 ft., Apr., Schonland, 3362; Port Elizabeth, Z. 2521; Rogers, 27616; Despatch, Holland, 424; Zuurberg Sanatorium, common on dry slopes, c. 2100 ft., Apr., Schonland, 3233; near Uitenhage and Grahamstown, E. and Z. 1866, Z. 2522; common on dry slopes near Grahamstown, numerous collectors; Koonap Heights, occasional along roadside cutting through

bush, Apr., Britten, 2052; Boschberg, Scott-Elliott, 477, MacOwan, 315; Cradock, Z.; Fort Cunynghame, near Stutterheim, May, 3200 ft., Galpin, 2427; Komgha, 2000 ft., Jan., Flanagan, 481; rocks near Murchison, 2000 ft., May, Wood, 3027.

De Candolle, in Prodr., iii, 385, suggested that this species might be allied to *Cr. pyramidalis*, for which I cannot see the slightest reason, nor can I see why Harvey in Fl. Cap., ii, associated it with his *Cr. deltoidea*. Its affinities are clearly with the *Harveyi* group. It is remarkably constant in its main characters. The following notes will supplement the description in the Fl. Cap.: The plant is usually about 30 cm. high. The leaves are almost flat (not subrecurved, they become so when dry), the base is truncate, not subcordate. The floral bracts are rough-edged, ciliate at the base, otherwise like the foliage leaves but much smaller. The sepals are green, very convex at the back, concave inside, slightly winged near the apex and at the very apex bluntly mucronulate (an almost unique character in sepals of Crassulas), slightly rough-edged, about $\frac{2}{3}$ the length of the base, lobes lanceolate, blunt. The petals are white, oblong-lanceolate, boat-shaped, almost free, at the apex dorsally mucronulate, 4–5 mm. long, erect (not recurved at the apex). Stamens nearly as long as the petals, filaments white, subulate, somewhat broader than in allied species, anthers brick-red, pollen yellow. Carpels slender, white, about as long as the stamens; styles subulate, about as long as the ovaries which pass gradually into them. Squamae minute, yellow, subquadrate, very deeply emarginate at the apex.

CYMOSA group (*Marginales* Harv. in Fl. Cap., ii, 333, p. pte.).

92. **Cr. cymosa** L., Syst. Veg., xiv, 304, Mant., 222; Harv. in Fl. Cap., ii, 342; Petiv. Gazoph., t. 89, fig. 6.

Cr. subulata E. et Z. (non L. nec Harv.) in Enum., No. 1904.

Globulea capitata Haw., Rev., 17 (ex Ind. Kew.).

Clanwilliam, Mader, 218; Hardveld, near Hopefield, Dec., Bachmann, 973, 974; Pikeniers Kloof, Z. 663; Tulbagh, E. and Z. 1904; Paarl, Benjamin, 761/18; 24-Rivers; Doornhoogde (Cape), E. and Z. 1904; near Capetown, Bolus, 3279; Cape Point, 800 ft., Jan., Schlechter, 7318; Diepriver Station, Jan., O. Kuntze; Cape, Drege, 6894.

This species has a superficial resemblance to the species described as *Cr. Sphaeritis* in Harv. and Sond., Fl. Cap., with which it has frequently been confused.

The following notes will supplement the description in the Fl. Cap.: Calyx-lobes $\frac{1}{2}$ the length of the petals, which are yellowish white, anthers pale yellow; styles and ovaries green, the latter minutely ciliate on the

inner margin ; squamae very small, pale yellow, broadly cuneate, rounded and emarginate at the apex.

A drawing by Haworth at Kew was labelled by him *Cr. cymosa* and briefly described by him as *Larochea* (?) *cymosa* in Syn. Pl. Succ., 50, with a reference to Willd., Sp. Pl., ii, 2548. Haworth's plant is clearly not *Cr. cymosa* L. and belongs to *Rochea*. Bergius' description of *Cr. cymosa* (Berg., Cap., 84 (1767)), agrees with *Rochea odoratissima* and is not Linneaus' species.

93. **Cr. flava** L. Mant., i, 60 ; Harv. in Fl. Cap., ii, 342 ; *Cr. cymosa* Thunb. in Fl. Cap., ed. Schultes, 284.

Cr. virgata E. Mey. in Herb. Drege.

Rochea flava DC., Prodr., iii, 393 (excl. Syn. Burm.).

Curtogyne flava E. et Z. in Enum., No. 1942.

Larochea (?) *flava* Haw., Syn. Pl. Succ., 50.

Herb. Linnaeus and Lamarck (in the latter reference is made to Pluk., t. 314, fig. 3).

In stony and sandy places at the foot of Table Mt., Dec.-Feb., E. and Z. 1942 ; MacOwan (Herb. Norm., 97), Bolus, 3364 ; Ecklon, 203 ; Bergius, O. Kuntze, and Lalande in Herb. Berol. ; rocky places, Camps Bay, Z. 5066, Rehmann, 1116 ; Crabouw, Britten, 3118 ; sides of Mt. Dal Josaphat, 1000 ft., Jan., Tyson, 887 ; hills near Sir Lowry's Pass, 500 ft., Jan., Schlechter, 7214 ; Tulbagh, Marloth, 1335 ; Drege in Herb. Berol. (*Cr. virgata* E. Mey.), is laxly leafy and has also much laxer inflorescence than usual.

In the live specimens I have seen, the petals are white in the upper part, yellow from below the middle downwards ; filaments white, anthers yellow ; styles red ; the small squamae green. The filaments are thicker than in allied species. *Cr. flava* in Willdenow's Herbarium is =*Cr. tetragona* L.

Neither Thunberg nor Linn. f. recognised this species.

In Thunberg's Herbarium the specimen which he wrongly took to be *Cr. cymosa* Berg., but which is *Cr. flava* L., is preserved. The same name is wrongly applied to No. 1 in the Linnean collection. No. 2 in this collection was named *Cr. flava*. This name has been crossed out by Linn. f. and "*cymosa*" substituted.

I have taken the plant represented by No. 2 of the Linnean collection as the type of *Cr. flava* L., but the matter may require further adjustment. Linnaeus based his species on two plates : Burm., Afr., t. 23, fig. 2, and Pluk., Alm., 340, t. 314, fig. 2. These figures are very poor and they may represent two species. Ecklon and Zeyher separated their 1943 as *Curtogyne Burmanniana* (*Cr. Burmanniana* Dietr.). This at all events seems to be distinct. The whole difficulty might be temporarily solved by calling the species *Cr. flava* (E. et Z.) Harv. (an Linn. ?).

94. **Cr. Burmanniana** D. Dietr., Syn. Pl., ii, 1032; *Cr. flava* L. p. pte. ?; *Curtogyne Burmanniana* E. et Z. in Enum., No. 1943.

Stony places (alt. II) at the foot of the Klynriviersberg (Caledon), Aug., E. and Z. 1943.

This was placed by Harvey and other authors under *Cr. flava*. Ecklon and Zeyher's originals show that it should be separated. The inflorescences are few-flowered, terminal and lateral. The mode of branching of the stem is sometimes as in Burm., Afr., 38, t. 23, fig. 2.

Ecklon and Zeyher unfortunately mixed with their specimens detached inflorescences of *Cr. albiflora* which can at once be recognised by their peculiar white setose papillae on the peduncle, pedicels and bracts, relatively shorter calyx-lobes than in *Cr. Burmanniana* and much longer, slender subapical mucro on the petals. The details of the flowers as shown by Burmann do not agree with Ecklon and Zeyher's specimens.

95. **Cr. dejecta** Jacq. in Hort. Schoenbr., t. 433; Harv. in Fl. Cap., ii, 343.

Cr. undata Haw., Suppl. (ex Harv.); DC., Prodr., iii, 392.

Curtogyne dejecta DC., Prodr., iii, 392.

Sandy places, campground near Capetown, Feb., Bolus, 2976; Riverzonderend, 700 ft., Jan., Schlechter, 9886; 24-Rivers, Du Plessis; amongst rocks on the mountain-sides in the Tulbagh Valley, alt. III, Dec., E. and Z. 1939; Klipfontein, Nov., Z. 2884; Paarl division, Marloth, 3455*b*; Malmesbury, Marloth, 6609.

Var. *minor* Schonl. Smaller in all parts than the type.

Cr. undulata Haw., Misc. (1803), 176, Syn., 53.

Curtogyne undulata DC., Prodr., iii, 392; Haw., Rev., 9.

Base of mountains near Capetown (E. and Z. 1940, Z. 7884, Z. 668; Bolus, 2976; U. I. 201); near Hopefield, Malmesbury division, on sandy ground, Dec., Bachmann, 968, 969.

Under "*Cr. ciliaris*" in Jacquin's Herb. at Vienna there is one sheet marked in pencil by Jacquin (?) *Cr. dejecta* Jacq., and may be looked upon as a type. Another from Banks is *Cr. ciliata* L. In Linnaeus' Herb., London, No. 36, named *ramosa*, is *Cr. undulata* Haw., not *ramosa* Thunb.

96. **Cr. albiflora** Sims in Bot. Mag., t. 2391; Harv. in Fl. Cap., ii, 343.

Cr. obvallata Thunb. (non Linn.) in Prodr., 56, Fl. Cap., ed. Schultes, 286.

Cr. dejecta Drege in Herb. Berol.

Cr. decussata Herb. Willd. (an *Cr. decussata* Spreng, Syst., i, 966 ?).

Cr. alba Hort. (ex Ind. Kew.).

Rochea albiflora DC., Prodr., iii, 393.

Curtogyne albiflora E. et Z. in Enum., No. 1941.

Both in Thunberg's and Linnaeus' Herb. (No. 8) the plants named *Cr.*

obvallata L. do not agree with Linnaeus' description in Mant., i, 61, and are *Cr. albiflora*.

In Lamarck's Herb. this species is mixed with *Cr. gentianoides* (=*Grammanthes gent.*).

Paarl, 500–900 ft., Jan., Tyson, 956, and Bolus (sine no.); in rocky ground, mountain-sides between French Hoek and Drakenstein (alt. III), Jan., E. and Z. 1941; Wellington, common in Protea scrub, Jan., Britten, 3160; Tulbagh Kloof, Z. 669, 699; Drakensteinberge, near Bainskloof, 1500 ft., Mar., Bolus, 4044; mountain-sides Hex River Valley, 1500 ft., Jan., Tyson; slopes at Groothoek, near De Doorns, 1700 ft., Jan., Bolus, 1040; Clanwilliam, Mader.

Var. *minor* Schonl. Flowers and leaves somewhat smaller than in the type. Internodes more elongated than in type and leaves, consequently not imbricated.

Gnadendal, 1000 ft., Dec., Schlechter, 9849 (very close to a plant labelled *Cr. albiflora minor* in Herb. Harvey). The following has even smaller leaves (less than 1 cm. long) but shorter internodes than Schlechter's plant: Clanwilliam, Rogers, 17000.

The following notes will supplement the description in the Fl. Cap.: The sepals are green, tinged with red, very convex on back; styles very distinct from the ovary (as in other species which have been placed by Haworth in his genus *Curtogyne*), but the ovaries can hardly be described as gibbous at the top on the inner side; the inner angle of the ovaries is minutely ciliate; the almost white and very minute squamae are fleshy, obcuneate, rounded, and slightly emarginate at the apex.

In Willdenow's Herb. at Berlin there is a specimen, received from Jacquin, named *Cr. decussata* Willd. It is certainly *Cr. albiflora* Bot. Mag. I cannot tell whether this is *Cr. decussata* Spreng, Syst., i, 966. *Cr. albiflora* leads up to some of the species placed by Harvey in sect. *Squamulosae* (Fl. Cap., ii, 333).

97. **Cr. rubricaulis** E. et Z. in Enum., No. 1892.

Aasvogelberg, near Albertinia, Muir, 847; Montagu Pass, Volschenk; Buffelsnek, Knysna, 2200 ft., May, Fourcade, 1261; Dubbelbay, Knysna, 1600 ft., Mar., Phillips, 19; along road leading to Knysna Heads, near sea-level, Jan., Williamson, 112; Formosa, Plettenberg Bay, 200 ft., Jan., Fourcade, 1055; Groot River Pass East, 400 ft., Mar., Fourcade, 1983; Uitvlugt, Humansdorp division, 1200 ft., June, Fourcade, 2637; Humansdorp, Rogers, 3105; stony places, Van Stadens Mts., alt. III, Feb., E. and Z. 1892; Earn Cliff, near Port Elizabeth, 300 ft., May, Galpin, 6461; Port Elizabeth, Mar., Kemsley, 295.

The flowers vary in colour, sometimes they are white, usually rosy.

Var. *Muirii* Schonl. Flowers as in the type; leaves about 1 cm. long,

acute or subacute, oblong, very convex on the back, almost flat on the inner side.

Langeberg, Mossel Bay division, Muir, 1302.

SCABRA group (*Squamulosae* Harv. in Fl. Cap., ii, p. pte.).

98. **Cr. scabra** L., Sp., 405; Dill., Elth., fig. 117; Berg., Descr. Cap., 84.

Cr. squamulosa Willd. in Enum. Hort. Berol., Suppl. 15 (non Harv.).

Cr. scabrella (Haw. ?) Harv. in Fl. Cap., ii, 345.

Globulea mesembrianthoides E. Mey.

This is a very variable species. The specimens in Willdenow's Herbarium at Berlin (received from Jacquin) and named *Cr. scabra* belong to the form which is called *Cr. squamulosa* (Willd. ?) in the Flora Cap., while *Cr. squamulosa* Willd. as represented in Willdenow's Herbarium belongs to *Cr. scabra* of the Flora Capensis. The three varieties which I distinguish are not separated by good technical characters. With reference to the third (*Cr. scabrella* of the Fl. Cap.) as contrasted with the second (*Cr. scabra* of the Fl. Cap.), Miss L. Guthrie wrote to me in Feb. 1921: "I have been watching them throughout the year and have always found them quite distinct. The smaller one flowers in Nov., Dec., the larger begins in January. Both are equally plentiful and grow in some cases side by side. The differences have nothing to do with climatic conditions, nor the soil. The scales on *scabrella* seem to me to be more obtuse than those on *scabra*."

Cr. bullulata Haw. in Rev. Pl. Succ., 11, DC., Prodr., iii, 385, is probably this species; while *Cr. bullata* Haw., *loc. cit.*, cannot be recognised.

(*a*) *typica* Schonl. (*Cr. squamulosa* Harv. [non Willd.]). Branches erect or suberect, leaves on an average about 2·5 cm. long. Type in Herb. Sherard, Oxford.

Sandy soil near Riebecks Kasteel, Nov., Z. 767; Gamka River, Z. 666; Worcester, 1000–2000 ft., E. and Z.; Tulbagh waterfall and Winterhoek, E. and Z.; Morreesburg, Nov., Bachmann, 688; also recorded by Harvey between the Paarl and Pont near the Berg River, Drege.

(*b*) *intermedia* Schonl. (*Cr. scabra* Thunb., Fl. Cap., ed. Schultes, 285; Harv. in Fl. Cap., ii, 345; *Cr. squamulosa* Willd.). More richly branched than (*a*), branches usually divaricate; leaves shorter (average about 1·3 cm.), and relatively broader. Bergius 19/2 17 in Herb. Berol.

Northern side of Table Mt., Tyson; amongst shrubs at the foot of Lion's Head, northern aspect, c. 300 ft., Jan., MacOwan, 2784 (Herb. Austr. Afr., 1847); hillsides round Capetown, Feb., E. and Z. 1886; Sir Lowry's Pass, 1400 ft., Jan., Schlechter, 7273; 24-Rivers, Dec., Du Plessis; ? Rogers, 3007 (locality on label erroneously given as Grahamstown).

Var. (*b*) is preserved in Herb. Thunberg and Herb. Lamarck. In the latter as "*Cr. scabra* L. var. *β*, enc."

(*c*) *minor* Schonl. (*Cr. scabrella* Harv. in Fl. Cap., ii, 345, an Haw. in Rev. Succ., 11 ?). Smaller in all parts than (*a*) and (*b*) (leaves less than 1 cm.) and much more diffusely branched. Harvey states in Fl. Cap. that in *scabrella* the calyx-lobes are $\frac{2}{3}$ of the corolla. I find that they are sometimes even relatively longer, but even in var. *intermedia* the length varies considerably.

Near Capetown, Dec., Marloth; rocky places near the blockhouse, Camps Bay, Dec., Z. 5068; Devils Peak, Rehmann, 1113; Table Mt., 500–3500 ft., E. and Z. 1887, Bolus, 3363.

The following notes, supplementary to the description in the Fl. Cap. of my var. *intermedia*, were taken from specimens kindly supplied by Mrs. F. Bolus:—

Petals white, almost strap-shaped, nearly free. Stamens nearly as long as the petals; filaments slender; anthers oblong ovate, reddish-brown; pollen yellow. Carpels nearly as long as the stamens; ovaries about as long as the styles, concave on inner side and minutely spinulose-ciliate on the inner angle; styles well defined, narrowly subulate; stigma minute. Squamae minute, obcuneate, slightly fleshy, pale green.

In Herb. Link a specimen of *Cr. scabra* L. is marked *Cr. pruinosa* L. Both Haworth (in Rev. Succ.) and de Candolle (in Prodr., iii, 385) state that *Cr. scabrella* Haw. stands between *Cr. scabra* and *Cr. squamulosa*, which makes the identity of Haworth's species very doubtful.

This is the appropriate place to make a few remarks on

The genus Dasystemon DC.

The type of this genus is *Dasystemon calycinum* A. P. DC. in Mémoire sur la famille des Crassulacées, Paris, 1828, p. 14, pl. iii; Prodr., iii, 382.

Cr. calycina Hort. Paris. (teste DC.); Desf. Tabl., ed. 2, 1815, 187.

Through the kindness of Professor Briquet I have had the opportunity to examine the two original specimens of this plant preserved in the Herb. de Candolle at Geneva. The author states that it came from Australia.

Bentham and Hooker in the Gen. Plant, i, 658, say of this plant: "*Dasystemon* est *Cr. expansa* Ait. species *capensis*, Fl. Austral., ii, 451."

As regards the origin of the plant, I agree that no crassulaceous plant outside South Africa is known with which it can be identified, or to which it can be related, but the statement that it is *Cr. expansa* can at once be dismissed. Bentham and Hooker cannot possibly have seen the plant, otherwise they would at once have come to a different conclusion. They

seem to have also overlooked the author's statement that "the leaves and stem are covered with small white papillae and scales," whereas *Cr. expansa* has quite smooth leaves and stem.

Comparing the plant now with other South African species of *Crassula*, it could be seen at once that its vegetative organs agree remarkably well with *Cr. scabrella* (Haw. ?) Harv. in Harvey and Sonder, Fl. Cap., ii, 345, a plant which is very common near Capetown. The question arises, therefore, whether it belongs to this species. At first sight this does not seem to be the case.

In *Dasystemon* the flowers are found singly in the bifurcations of the stem, in *Cr. scabrella* they form terminal subsessile subcorymbose inflorescences. The distinguishing characters of the flowers as stated by de Candolle also do not lead to *Cr. scabrella*.

They are: (1) the flowers are 3–7-merous; (2) the sepals are large, unequal, and similar to real leaves ("feuilles véritables"); (3) the filaments are short, thick, almost ovoid, and according to the author suffice to characterise the genus.

Unfortunately on pl. iii, figs. 1, 2 of de Candolle's memoir two flowers are represented with long, thin, filamentous filaments. It is impossible to decide whether perhaps the author has described the filaments from young buds and the draughtsman has taken old flowers, or whether the draughtsman has made extraordinary mistakes, or, lastly, whether both types of filaments have occurred. There are only two flowers preserved; in one the stamens seem to have disappeared, in the other the anthers have not discharged their pollen yet and the filaments (which cannot be seen without dissection) seem to be very short.

While it is not possible to express a decided opinion on this plant, I think I am justified in suggesting that it is *Cr. scabrella* with abnormal flowers and inflorescences due to cultivation under abnormal conditions. I have in other species of *Crassula* also found extraordinary variations in floral structure due to cultivation, though nothing so striking as I assume in this plant.

99. **Cr. pruinosa** L., Mant., i (1771), 66, Syst. Veg., xiv, 304; Thunb., Prodr., 55, Fl. Cap., ed. Schultes, 283; DC., Prodr., iii, 385; Harv. in Fl. Cap., ii, 346.

Type in Herb. Linnaeus, No. 4; also in Herb. Thunberg.

24-Rivers, alt. III, Dec., Z. 665; Boschkloof and Blaauwberg, Drege, 6906 (ex Harv.); Koude Bokkeveld, in mountains near Tandfontein, 4500 ft., Jan., Schlechter, 10140.

100. **Cr. divaricata** E. et Z. in Enum., No. 1891; Harv. in Fl. Cap., ii, 339.

In the Karroo behind the Langekloof, George, E. and Z. 1891; Nama-

qualand, Steinkopf, Dec., Max Schlechter, 42 ; Little Namaqualand, Scully ; Wittebergen, near Matjesfontein, Marloth, 10853.

Schlechter's and Scully's specimens are placed in the British Museum Herb. under *Cr. Whiteheadii* with a remark, "compared with the type." I must admit they agree fairly well with the description of this species by Harv. in Fl. Cap., ii, 346, but a comparison of E. and Z.'s, Scully's and Schlechter's specimens in the Herb. of the Albany Museum shows that they cannot be distinguished as regards size and outline of the vegetative organs, and that as regards the possession of papillae they form a series which, I think, does not admit of their being separated specifically. Perhaps it would be wisest to scrap *Cr. Whiteheadii* Harv.

Notes additional to the description in the Fl. Cap. were published in Journ. of Bot., xl, 282. Harvey associated this species with *Cr. perforata* and *Cr. perfossa*, to which, however, it cannot be nearly related.

101. **Cr. Whiteheadii** Harv. in Fl. Cap., ii, 346.

Ezelsfontein, Namaqualand (ex Harv.). Only known to me from the description.

102. **Cr. petraea** Schonl. n. sp.

Herbacea laxe ramosa c. 6 cm. alta, ramis adscendentibus dense foliatis. Folia crassa suberecta saepius leviter incurva sessilia connata ambitu oblongo-lanceolata, extus valde convexa intus subplana, juvenilia scabrida ad margines ciliata, ciliis setosis brevibus patentibus, adulta ± glabra, c. 1 cm. longa. Pedunculus terminalis gracilis scabridus bractearum vacuorum paribus 1–2 instructus, bracteis lanceolatis acutis scabris. Cyma terminalis pauciflora, floribus pedicellatis, pedicellis c. 2 mm. longis. Sepala leviter connata, lobis triangulari-lanceolatis dorso scabridis margine ciliatis, $1\frac{3}{4}$–$2\frac{1}{4}$ mm. longis. Petala connata linguaeformia, subacuta, dorso infra apicem mucronata, $4\frac{1}{2}$ mm. longa, tubo 1 mm. longo. Stamina 2–$2\frac{1}{2}$ mm. longa. Carpidia gracilia, ovariis oblique oblongis, stilis recurvis gracilibus, stigmatis parvis capitatis. Squamae minutae obcuneatae rotundatae.

Steinkopf, Little Namaqualand, Marloth, 12491. Type in Herb. Marloth.

Cr. petraea seems to be allied to *Cr. Whiteheadii* Harv., a species of which unfortunately I have not seen an original. However, the descriptions differ in so many details that it seems to be safe to keep them separate.

103. **Cr. pallens** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 361.

Karreeberge, c. 1500 ft., Schlechter. Type in Herb. Albany Mus.

104. **Cr. dregeana** Harv. in Fl. Cap., ii, 346.

Cr. squamulosa E. Mey. in Herb. Drege.

Cr. longistyla Schonl. in Rec. Albany Mus., ii, 457.

Between Omsamculo and Omcomas, Drege ; Pondoland, Beyrich, 33, in Herb. Berol. ? (specimen poor) ; Natal ?, anno 1907, Sim in Natal Gov. Herb., 11902.

PERFOLIATA group (*Glaucinae* Harv. in Fl. Cap., ii, 332; *Rochea* spp. auct.).

105. **Cr. perfoliata** L., Sp. Pl., 282 (ex Ind. Kew.); Hort. Cliff., 116; Wach. Ultraj., 50; Kniph. Cent., 10, No. 31; Roy. Lugd. Cat., 455; Mill., Dict., 2 et icon., t. 108; Ait. Hort. Kew., i, 390, No. 2; Comm. Prael., 74, t. 23; Thunb., Prodr., 56, and Fl. Cap., ed. Schultes, 286; Haw., Syn. Pl. Succ., 51; Harv. in Fl. Cap., ii, 338.

β albiflora Harv. in Fl. Cap., ii, 338; DC., Pl. Gr., t. 13; Dillenius, Hort. Elth., 114, t. 96, fig. 113.

Cr. pallida Bak. in Gard. Chron. (1874), i, 786; Wood, Natal Plants, iv, t. 323.

Cr. heterotricha Schinz in Beitr. zur Kenntniss der afrik. Flora (Neue Folge), ii, 203.

The type is in the Sherardian Herb., Oxford; the species is also represented in Thunberg's Herb.

Common in karroid scrub in S.E. Cape Province, extending eastwards to the Northern Transvaal; stony hills near Graaff Reinet, common, 2500–5000 ft., Dec., Bolus, 812; Bruintjeshoogde, 3000 ft., MacOwan, 440; Greenbushes, near Port Elizabeth, Paterson, 441; banks of the Baakens River, Kensit in Herb. Bolus; Karroo-like places, Sundays River, E. and Z. 1945, Z. 351, Z. 983; Hell Poort, Dec.–Jan., MacOwan, 440 (also found in numerous other places near Grahamstown, *e.g.* Koonap Heights and Fish River bush, Schonland, 248); Port Alfred, Jan., Rogers; East London, Apr., Rattray, 24; Pondoland, Bachmann, 527; Midland districts of Natal and Zululand (*e.g.* Umbumbulu, in crevices of rocks, 800 ft., Wood, 6479; Mid-Illowo, on perpendicular rocks, Sept., Sim); Barberton, June, Thorncroft; Louis Trichard, Marloth, 10199.

This species varies considerably. The colour of the flowers may be white or red. Baker, in separating *Cr. pallida*, says: As compared with *Cr. perfoliata* petals oblong and blunt instead of lanceolate acute, white instead of bright red, and shorter both absolutely and in proportion to the calyx. This is true if one compares *e.g.* Wood, 6479, and Schonland, 248, but the difference is scarcely noticeable in Bolus, 612, which Baker quotes as the type specimens of his *Cr. pallida*. Thorncroft's specimen from Barberton has narrower, lanceolate (instead of lanceolate-deltoid) calyx-lobes. The ovaries may be minutely glandular or glabrous except for minute cilia along the inner margin. Again the inflorescence varies considerably. It may be very loose or cymose-corymbose, rarely globose.

The vegetative organs are fairly uniform except in some Natal specimens which have a more or less prostrate, richly branched stem with leaves only 3–3·5 cm. long. The flowers in these specimens have no distinctive

characters, the inflorescences are smaller and have fewer flowers, but amongst Sim's specimens from Mid-Illowo is one which passes into the usual habit of the species. As represented in Herb. Lamarck this species has thick leaves only about $1\frac{1}{4}$ in. long.

106. **Cr. falcata** Wendl. in Beobacht., 44 (ex Ind. Kew.); Willd., Enum., 340; Bot. Mag., t. 2035; Pole Evans, Plants of South Africa, t. 12; Harv. in Fl. Cap., ii, 338.

Cr. swellingrebliana Hort., Batav. (teste de Candolle).

Cr. obliqua Bergius in Herb. Berol.; Haw. in Andr. Bot. Rep., t. 414.

Cr. linguaeformis Herb. A. Braun, Berlin.

Cr. decussata Hort. ex DC., Prodr., iii, 393.

Cr. retroflexa Meerb., Pl. Select. Ic., t. 16 (non L. nec Thunb.).

Rochea falcata DC., Pl. Gr., t. 103, Prodr., iii, 393; E. et Z., Enum., No. 1944.

Larochea falcata Haw., Syn. Pl. Succ., 50; Tratt, Thes., t. 20.

Fairly common in dry rocky places in the S.E. Cape Province, but seems to extend to Natal.

Uitvlugt, Humansdorp division, 1200 ft., July, Fourcade, 2621; Uitenhage and Grahamstown, E. and Z., No. 1944, Z. 2561; Bruintjeshoogde, 3000 ft., Feb., MacOwan, 1723; near Zuurberg Sanatorium, Mar., Holland, 205; Alicedale, Feb., Cruden, 201; common near Grahamstown, MacOwan, 2246; Egossa, East Pondoland, Aug., Sim, 2549.

I have not seen Sutherland's specimens from Natal quoted by Harvey, (*loc. cit.*, 338). Mr. J. G. Baker wrote that they can hardly belong here as the upper leaves are long. He also wrote: *Cr. argentea* Thunb. in his Fl. Cap., 289, must be carefully compared with this species. However, this is =*Cr. portulacea* Lam.

Southi group.

Rather isolated. The only species has usually the habit of *Cr. Harveyi* Britt. et Bak. f., but the leaves are papillose-ciliate on the margin and the young branches are scabrous. It is distinctly suffruticose.

107. **Cr. Southi** Schonl. in Journ. Linn. Soc. (Bot.), xxxi (1897), 530; *Cr. mucronata* Keissl. in Ann. Hofmus. Wien, xv, 38, fig. 5.

Near Alicedale, Penther, 2333, 2380, in Herb. Vienna; Alexandria, abundant in grass veld, Jan., Burtt-Davy, 12103; near Port Alfred, Dec., South, 841; Round Hill, grassy flats, Dec., Britten, 5027; Trapps Valley, Dec., Daly, 568; Perie, Apr., Godfrey, 17; Evelyn Valley, Jan., 4000 ft., Sim, 1271; Nquamakwe, Jan., Bolus, 8906.

VAGINATA group (*Marginales*, Harv. in Fl. Cap., ii, 333, p. pte.).

This group is well represented on the mountains of Tropical Africa and extends only slightly west of the Uitenhage division.

Cr. indica should also be placed here.

108. **Cr. vaginata** E. et Z. in Enum. (1837), No. 1903; Harv. in Fl. Cap., ii, 341; *Cr. abyssinica* A. Rich, var. *vaginata* Engl. in Pflanzenwelt Ostafrikas (1895), 189; ? *Cr. sulphurea* Kze. in Linnaea, xvii (1843), 573; *Cr. ciliata* β *acutifolia* E. Mey.; *Cyrtogyne* n. sp. Benth. in Pl. Plant., 82 (ex Harv.).

Common in grass veld and on mountain-tops; Zuurberg Sanatorium on slopes, 2100 ft., Apr., Schonland, 3244; common near Grahamstown (MacOwan, 35, and other collectors); Kleinemonde, near Port Alfred, White, 958; near Phillipstown, Kat River, alt. III, June, E. and Z. 1903; Hogsback, Rattray; near Ghulukop, Amatolas, 4000 ft., Feb., Dyer, 398; Komgha, 2000 ft., Mar., Flanagan, 673; Kentani, 1000 ft., Mar., Pegler, 439; Ugie, Maclear division, 4300–4500 ft., Jan., Britten, 4659; Bazija Mt., 2500 ft., Nov., Baur; Umtata, 3500 ft., Jan., Schlechter, 6334; Pondoland, Bachmann, 531; Egossa, E. Pondoland, Aug., Sim, 2550; Kokstad, 5000 ft., Tyson, 1310; near Cedarville, Mar., Bandert, 162; common all over Natal (teste Bews); Inchanga, Aug., Engler, 2689; Drakensberg, near De Beer Pass, 5000–6000 ft., Mar., Wood, 6036; O.F.S., Cooper, 1119; Saddleback Mt., Barberton, 5000 ft., Feb.–Mar., Galpin, 816; Lydenburg, Wilms, 539, 532, 535; a number of other Transvaal records are quoted by Burtt-Davy in Flowering Plants and Ferns of the Transvaal and Swaziland, 1925, p. 140.

Specimens collected by Miss M. Stewart in Swaziland (Herb. S.A. Mus., 3674, Hlatikulu) have very narrow leaves. They are up to 10 cm. long and only 3 mm. broad at the base. A specimen which must also probably be referred to *Cr. vaginata* was collected by O. Kuntze at Glencoe, 1500 m. It was named by him *Cr. crassifolia* O. K. n. sp.

109. **Cr. abyssinica** A. Rich in Tent. fl. Abyss., i (1847), 309; Britten in Oliv. Fl. Trop. Afr., ii, 338.

Var. *transvaalensis* Schonl. n. var. (*Cr. abyssinica* A. Rich in Burtt-Davy, Flowering Plants of the Transvaal and Swaziland (1925), 140). Differs from Schimper's type: Flowers slightly larger, sepals only denticulate at the apex, petals without distinct mucro, but slightly thickened at the apex, style barely ⅓ the length of the ovary, stem and branches of the inflorescence with scanty hairs.

Pilgrims Rest, Lydenburg, May, Rogers, 14625.

I have previously (Engl. Bot. Jahrb., xliii, 359) divided this species into six varieties, with none of which it agrees exactly.

Var. *angolensis* Schonl. in Engl. Bot. Jahrb., xliii, 360.

Hlatikulu, Swaziland, Stewart, 3675, in Herb. S.A. Mus.

110. **Cr. drakensbergensis** Schonl. in Bull. de l'herb. Boiss., v (1897); Schonland in Rec. Albany Mus., iii, 56 (amended description from live material).

Van Reenen, 5400 ft., Mar., Schlechter, 6962; Didcot, Mooi River, Sim.

111. **Cr. natalensis** Schonl. in Bull. de l'herb. Boiss., v (1897).

Wood, Natal Plants (1899), t. 63. (In the accompanying description, for " stamens 10 " read " stamens 5 ")

Cr. sessilifolia Bak. f. in Bull. de l'herb, Boiss., 2 ième série, 1903, 815, t. 3.

Amawaqua Mt., 6000–7000 ft., Apr., Wood, 4637; near Greytown, 4000–5000 ft., Wood, 4337; near Karkloof, Wood, 4484; Illowo, Apr., 1800 ft., Wood, 1876; Fort Nottingham, Mar., Wood, 6765; Culvers, Weenen, 6000 ft., Rogers, 17820, 28370; Leribe, Basutoland, Dieterlen, 676.

Like allied species *Cr. natalensis* varies in several respects. The colour of the petals is white or red. In Wood, 1876 the flowers are slightly smaller than in the type and have shorter and broader calyx segments.

A live specimen received from Professor Moss in March 1919, which had been sent from Durban without further details, had more closely set leaves, denser inflorescence and sepals which were covered with delicate papillose cilia on the margin. It may be distinguished as var. *Mossii* Schonl. The following detailed notes were taken from it :—

Perennial. Stem ascending about 9 inches long with an additional 1–2 inches for the inflorescence. In the specimen described the main stem, which had flowered in the previous season, was efoliate, showing rings (3–5 mm. distant) marking the leaf insertions, and was decumbent, about 8 mm. in diameter, getting thinner near the floral region. It bore three lateral branches (12–17 cm. long) which were upright, efoliate at the base (where the axis was like that of the main stem but slightly thinner). The remainder of the axis bears numerous leaves, very close-set and distinctly 4-ranked, for about $\frac{2}{3}$ of its length, then getting more open as the leaves become smaller. Younger parts of axis retrorso-pilose-pubescent. Leaves ovate-spathulate obtuse or slightly acuminate, connate, dark green (the older reddish), fleshy, slightly concave on the inner side, slightly convex on the outer, glabrous, with numerous slight circular depressions especially on inner side (punctate), margin densely beset with retrorse, narrow, pointed papillae, lowest about 30 mm. long, about 17 mm. broad in the broadest part, upper gradually smaller, passing gradually into the bracts. Inflorescence corymbose, ultimate cymes subumbellate. Pedicels short, glabrous.

Sepals almost free, pale green or tinged with red, ovate-lanceolate, acute, fleshy, dorsally slightly convex, glabrous, margin with fine papillae which point upwards, c. 2·25 mm. long. Petals white, sublingulate, with dorsal mucro, 3 mm. long, erect, slightly connected at the base. Stamens c. 2·75 mm. long. Filaments subulate about 2·25 mm. long. Anthers oblong, pale yellow. Pollen yellow. Carpels slightly shorter than the filaments, with short thick style. Squamae membranous obcuneate, apex emarginate, very pale greenish.

Three specimens communicated by Dr. van der Bijl and collected by Miss H. Forbes at Isipingo above water-high mark, Apr., 1921, are also referred by me to *Cr. natalensis*, but show some striking variations. Unfortunately they only represent the upper portions of three plants.

1.	2.	3.
Leaves pale green, closely set, diminishing gradually in size into the floral region.	Leaves dark green.	Leaves pale green.
	Laxly leaved.	Laxly leaved.
Internodes about 6 mm. long.	Internodes about 12 mm. long.	Upper internodes longer than the lower, up to 2·5 cm. long.
	Inflorescence thyrsoid.	Inflorescence subcorymbose.
Cymes in the axils of the upper leaves and terminal, subsessile.	Cymes more or less pedunculate.	
Calyx reddish, almost glabrous.	Calyx green, minutely pubescent.	Calyx very pale green, glabrous.
Lobes oblong-ovate blunt, but distinctly apiculate.	Lobes thicker than in 1, subacute, apiculate.	Lobes ovate-lanceolate, thinner than in 1 and 2, not apiculate.
Petals white, erect, bluntly mucronate behind apex.	Petals as in 1.	Petals as in 1, but apex more drawn out into an acute point.
Stamens about $\frac{3}{4}$ of petals,' filaments connected to base of petals, subulate, somewhat flattened, white, anthers broadly oval, yellow.	Stamens as in 1.	Stamens as in 1.
Carpels shorter than the stamens, style subulate, rather thick, a little shorter than the ovaries.	Carpels as in 1.	Carpels as in 1.
Squamae colourless, broadly obcuneate, rounded and emarginate at the apex.	Squamae similar to 1, but not quite so deeply emarginate.	Squamae obcuneate, rounded and deeply emarginate at the apex.

112. **Cr. spectabilis** Schonl. in Rec. Albany Mus., ii (1913), 453.

Eutumene, Zululand, 4000–5000 ft., Apr., Wylie. Type in Natal Government Herbarium, No. 9344.

113. **Cr. acinaciformis** Schinz in Beitr. zur Kenntniss der afr. Flora (Neue Folge), ii (1894), 204 ; Hook., Ic. Pl., t. 2530 ; *Cr. aloides* N. E. Br. in Kew Bull. (1896), 161 ; *Cr. inaequalis* Schonl. in Rec. Albany Mus., ii (1913), 452.

Damp places on hillsides (teste Burtt-Davy), exposed dry situations, *e.g.* railway banks in southern Pietersburg, Lydenburg, and Barberton districts (teste Rogers) ; Houtbosch, Rehmann, 6375 ; Transvaal, Marloth, 5348 ; Swaziland, Mar., Stewart, 108, 3682.

114. **Cr. rubicunda** E. Mey. in Fl. Cap. ii, 341 ; *Globulea stricta* E. Mey. (ex Harv.).

The key which J. G. Baker (Bull. de l'herb. Boiss., 2 ième série (1903), 814) gave of *Cr. rubicunda* and some allied species is useless.

Burtt-Davy in Flowering Plants and Ferns of the Transvaal and Swaziland (1925), 139, gives the following key, which also leaves much to be desired :—

Stem leaves linear or linear-lanceolate to oblong-lanceolate. Fl. 3–4 mm. long ; calyx-lobes $1{\cdot}5 \times 0{\cdot}5$ mm. ovate ; petals 3–$4 \times 1{\cdot}5$ mm. . *Cr. Wilmsii* Diels.

Fl. 4–5 mm. long ; calyx-lobes 1·5–2 mm., narrow linear-lanceolate acuminate, less than 1 mm. broad, stem rough, leaves 10–15–20 cm. long, petals keeled, *Cr. rubicunda* E. Mey.

Fl. 5–7 mm. long ; calyx-lobes lanceolate acute, 3·5–4 mm. long, more than 1 mm. broad, petals 5–$7 \times 1{\cdot}2$ mm. . . . . . . *Cr. Stewartii* Burtt-Davy.

Fl. less than (4 ?) mm. long (smaller than in *rubicunda*) ; calyx-lobes oblong-lanceolate ($\frac{2}{3}$ the length of the petals) ; stem cartilaginous-hispid ; lower leaves lanceolate or oblong-lanceolate 5–8 cm., upper leaves lanceolate or oblong, laxer and smaller . . . . *Cr. similis* Baker f.

Stem-leaves (at least the upper) ovate-lanceolate to ovate, infl. cymose-corymbose (as is the case in the other species) ; fl. 5–7 mm. long ; calyx-lobes linear-lanceolate keeled, almost as long as the corolla ; stem and branches of the cyme retrorsely papillate ; bracts densely retrorsely ciliate ; basal and median stem-leaves ?, upper stem leaves $3 \times 0{\cdot}9$ cm. acute . . *Cr. milleriana* Burtt-Davy.

I place all these species under one variable species : *Cr. rubicunda* E. Mey.

It varies chiefly in the size of the flowers and the relative length of the floral parts, secondly in the nature of the trichomes on stems and other organs ; these may be even absent on the stem, but a sharp division cannot be made. I propose tentatively the following varieties :—

(*a*) *typica.* Calyx-lobes at least $\frac{2}{3}$ of petals, subulate-lanceolate acute, ciliate and keeled ; petals 5–7 mm. long ; stem with blunt rather broad papillae ; upper leaves lanceolate. To this must evidently be referred the

plants quoted by Harvey in Fl. Cap., ii, 342, which unfortunately I have not seen and I further refer to it.

Richmond, 2800 ft., Apr., Wood, 9915 ; Mvanyeni, near Cedarville, Griqualand East, rocky hillside, not very common, Mar., Bandert, 161 ; amongst rocks, Klipriviersberg, Johannesburg, May, Bryant, D 21 ; Pyramid estate, Potgietersrust on banks of Polaji River, 4500 ft., Feb., Galpin, 8975 ; Standerton, Jan., Leendertz, 11112.

(*b*) *milleriana* Schonl. (*Cr. milleriana* Burtt-Davy, *loc. cit.*, 38). Similar to (*a*) with tendency for the upper leaves to become ovate lanceolate.

Hlatikulu, Swaziland, Stewart, 135 (p. pte.) in Herb. S.A. Mus.

(*c*) *similis* Schonl. (*Cr. similis* Bak. f., *loc. cit.*, 814). According to the author this differs from the type by the stem leaves being broader and shorter and connate at the base to a less extent, the flowers smaller. The sepals are $\frac{2}{3}$ the length of the petals. The stem is cartilaginous-hispid.

Houtbosch, Rehmann, 6374 (not seen by me) ; Giant's Castle (Natal), Jan., Roberts, 334, may have to be placed here. At all events the upper leaves are much broader than usual and the flowers agree with description.

(*d*) *hispida* Schonl. Floral structure as in the type or calyx-lobes dorsally not carinate and glabrous. Broad papillae of stem replaced by very narrow, pointed ones (resembling ordinary hairs). In this var. the leaves have a tendency to become slightly auriculate at the base.

Mt. Currie, 5500 ft., Jan., Schlechter, 6573 ; Leribe, Basutoland, 5000–6000 ft., Dieterlen, 239 ; Basutoland, Jan., Martin, 1148 ; slopes of Dooley, Mont aux Sources, common in grassland, 6500 ft., Feb., Bayer and M'Lean, 166 ; Didcot, Mooi River, Mar., Sim, 3 ; on rocky mountains, Houtbosch, district Pietersburg, c. 4900 ft., Feb., Bolus, 10958 ; Belfast, 6500 ft., Burtt-Davy, 1348 (wrongly named by me previously *Cr. stachyera γ pulchella*). The last one shows the auriculate bases of the leaves in the floral region most distinctly. It is much more branched than any other plant referred to *Cr. rubicunda* ; Carolina, Dec., Rademacher, 7487 ; Ermelo, Jan., Collins, 6318 ; Wákkerstrom, Jan., Van Dam, 24307 ; Acornhoek, May, Roberts, 26205. To this variety must also be referred *Cr. Stewartii* Burtt-Davy (*loc. cit.*, 38) collected by Miss M. Stewart at Hlatikulu in Swaziland, No. 135, p. pte. in Herb. S.A. Mus. This has a distinct tuberous rootstock, which is also indicated in some other specimens belonging to this species.

The following are somewhat intermediate between (*a*) and (*d*), especially in so far as they have pointed papillae on the stem (a transition between the broad blunt ones of (*a*) and the hair-like ones of (*d*)) :—

Hlakitulu, Swaziland, Stewart, 2568, in Herb. S.A. Mus. ; Shiluvane, Junod, 5001, in Herb. Transv. Mus. ; Lomati, near Barberton, Jan., Thorn-

croft, 5000, in Herb. Transv. Mus.; Utrecht, Jan., Wahl, 15538; Ermelo, Oct., Leendertz, 7763.

(*e*) *parvisepala* Schonl. (including *Cr. Wilmsii* Diels in Engl. Bot. Jahrb., xxxix (1907), 464). Flowers smaller than in other varieties, petals not more than 4 mm. long, sepals less than ½ the length of the petals, stem papillose or papillose-hispidulous.

Spelonken, fl. in Pretoria, Mar., Gray, 12188 (sepals broad); Lydenburg, Wilms, 538 (sepals narrow); Zoutpansberg, Apr., Junod, 5001 (sepals broad).

(*f*) *subglabra* Schonl. Stem subglabrous, sepals nearly ⅔ the length of the petals.

Empangeni, Zululand, 200 ft., Nov., Sim, sine no.

(*g*) *flexuosa* Schonl. Stem much elongated, subglabrous (papillae hair-like), flexuous, lower internodes about 20 mm. long, upper gradually smaller. Leaves lanceolate acuminate, faintly auriculate at the base, lowest about 5 cm. long, upper gradually smaller. Inflorescence very loosely cymose-corymbose, lowest bracts leaf-like. Calyx nearly as long as corolla. Heidelberg, Nov., Leendertz, 9986, in Herb. Transv. Mus.

(*h*) *lydenburgensis* Schonl. Vegetative organs similar to (*g*), though internodes not quite so long. Stem sparingly covered with broad, blunt papillae. Calyx about ½ the length of the petals, lobes broadly lanceolate.

Lydenburg, Wilms in Herb. Mus. Trans.

The following specimens of the Berlin Herb. were placed by me under *Cr. rubicunda*, but cannot at present be assigned to its varieties.

Pondoland, 200–500 ft., Beyrich, 23, Bachmann, 528 (similar to Wood, 409); Natal, 800 ft., Apr., Wood, 409 (a rather small-flowered form with elongated stem); Lydenburg, Dec., Wilms, 533 (a very robust plant with thick stem and richly branched rather lax inflorescence).

115. **Cr. recurva** N. E. Br. in Gard. Chron., ii (1890), 654.

Zululand, Wood.

Although the leaves are covered all over with reflexed papillose hairs and there are no distinct marginal papillae, I place it next to *rubicunda*, which it approaches in floral structure. The flowers are rosy purple.

116. **Cr. crenulata** Thunb., Nova Acta Nat. Cur., vi, 1778, 329, 332, Prodr., 56, Fl. Cap., ed. Schultes, 287; L. f., Suppl., 189; Linn., Syst. Veg., xiv, 307, Sp. Pl. (ed. 4), 1563; Harv. in Fl. Cap., 344

? *Cr. caerulata* J. F. Gmel., Syst., 518 (ex Ind. Kew.).

Harvey queries whether his plant is Linnaeus' species. However, Thunberg is the author, and his type is in his Herb. at Upsala.

Cr. telephioides Haw. in Rev. Pl. Succ., 9, is represented at Kew by one of Haworth's drawings. It should be compared with *Cr. crenulata*.

Robinson Pass, Outeniqua Mts., Taylor, 317 (flowers shorter than usual);

Assegai Bush, near Payne's, Humansdorp division, Jan., Britten, 1246; wooded kloofs, 2 miles east of Assegai Bush, 700 ft., Mar., Fourcade, 2187; Van Staaden's Mt., Z. 2530, 980, Ecklon, 390, Bolus, 1510 (800–1500 ft.); Thornhill, 3 miles west of Van Staaden's Pass, Jan., Daly, 907 (Thunberg's locality is close by); in light bush near Grahamstown, *e.g.* bottom of Woest Hill and Featherstone's Kloof, Jan.–May, MacOwan, 777; along road, Cunynghame plantation, Stutterheim division, 3000 ft., Jan., R. Schonland, 54, 33; Windvogelberg, near Cathcart, Feb., Sim; East London, Apr., Rattray, 28; Kei Road, 1500 ft., Mar., Sim, 1213; Keimouth, 200 ft., July, Flanagan, 221; grassy hills near Komgha, 2000 ft., Mar., Flanagan, 763; Kentani, grassy slopes, frequent, 1000 ft., Feb., Pegler, 1167; Bazija, 2000 ft., Jan., Baur, 587; slope towards Umtata waterfall, not common, Dec., Schonland, 3802; Tsolo, Payne, 18; near Engcobo, Jan., Bolus, 8907; in damp rocky places near Clydesdale, Griqualand East, 2500 ft., Feb., Tyson, 2977; Inanda, Natal, Wood, 497.

The following notes will supplement the description in the Fl. Cap.: Calyx-lobes green with purple tips, quite glabrous, subacute, dorsally sub-umbonate below the apex, 2 mm. long. Petals white at the base, passing into pale purple with narrow white margins in upper half, suberect, oblong, below the apex dorsally mucronulate, 6·5 mm. long. Filaments white with a rosy tinge, lineate, constricted at the apex. Anthers small, broadly ovate. Carpels white with a rosy tinge, slender, with subulate styles which nearly equal the ovaries in length. Squamae minute, obcuneate, rounded and slightly emarginate at the apex, somewhat fleshy, yellow.

The width of the leaves varies from less than 6 mm. to 4 cm. The length is also very variable, from about 2·5 to 7·3 cm., but in spite of this it is an easily recognised species, which branches from the base, the branches being usually about 35 cm. long. The leaves are concave on the inner side, convex and slightly carinate at the back, sometimes they are acuminate.

RAMULIFLORA group (*Marginales* Harv. in Fl. Cap., ii, 333, p. pte.).

117. **Cr. ramuliflora** Link et Otto in Ac., 3. Heft (1821), cum icon.

(*a*) *typica.* Leaves ovate, acuminate, about 1·8 cm. long. Calyx ½ the length of the white petals; in all other varieties the length of the calyx exceeds considerably ½ the length of the petals. (From the author's description and figure; see, however, *Cr. Meyeri* Harv.); Schumann in Sukkulenten (1892), fig. 55.)

(*b*) *Flanagani.* Leaves ovate acute, 2·5 cm. long. Petals white. Rocky slopes near Komgha, 1000–2000 ft., Mar., Flanagan, 651, 662; Prospect Farm, Komgha, 2000 ft., Apr., Pegler, 1820; amongst rocks near East Gate, Port S. Johns, 1000 ft., Apr., Galpin, 2876; Cala district,

c. 4000 ft., Mar., Pegler, 1530; near Cedarville, Griqualand East, Mar., Bandert, 159.

(*c*) *stachyera* (*Cr. stachyera* E. et Z. in Enum., No. 1897; Harv. in Fl. Cap., ii, 343; *Cr. perforata* E. Mey. ex Harv. in Fl. Cap., ii, 344). Leaves broadly obovate or elliptic-oblong or oblong, subobtuse. Petals reddish.

This variety can be split up into a number of growth forms, but no useful purpose could be served by giving them names. The form which Ecklon and Zeyher and Harvey put under *Cr. stachyera* is common in rocky places near Grahamstown and Somerset East, *e.g.* MacOwan, 1210 (amongst shrubs mountain-side of Boschberg, 3000–4000 ft., Mar.). In this the inflorescence is interruptedly subspicate (or occasionally more richly branched); the leaves and the bracts of the cymules are distinctly acute. The following are similar :—

Zuurberg, Mar., Holland, 23; Atherstone, Apr., White, 507, Daly and Sole, 449; Daggaboer; Bedford, Nicol, 36; Katberg, Mar., Galpin, 2051 (in this, however, the inflorescence is subcorymbose); Windvogelberg, near Cathcart, Feb., Sim; grassy mountain-sides, Queenstown, 4000 ft., Feb.–Mar., Galpin, 2023; Andriesberg, 4750–5300 ft., Feb., Galpin, 2003; Kingwilliamstown, 1500 ft., June, Sim, 1230.

(*Cr. inchangensis* Engl. in Engl. Bot. Jahrb., xxxix (1907), 466. The type, found by Engler (No. 2687) above Inchanga, Natal, on rocks at an altitude of about 750 m., is in Herb. Berol., now united by him with *Cr. stachyera.*)

Then there are forms in which the leaves are subacute or almost obtuse, *e.g.* Brookhuizens Poort, near Grahamstown, Feb., MacOwan; Zuurberg, Mar., Holland, 24.

Forms with obtuse or subobtuse leaves and more or less richly branched inflorescences, *e.g.* Zuurberg, Apr., Paterson, 12; Donnybrook, Natal (cultivated in Natal Bot. Gardens, No. 648). The last has a subcorymbose inflorescence.

According to a drawing by Haworth in the Kew collection, representing a plant raised from seeds received from Bowie, in 1821, and named *Cr. punctata* Haw., this seems to belong here. Whether this is the following is not quite clear: *Cr. punctata* L., Sp. Pl., 406, Syst. Nat., ed. 10; Ait. Hort. Kew., ed. 2, ii, 193; Rai Suppl., 118; Willd., Sp. Pl., i, 1553; DC., Prodr., iii, 383; Harv. in Fl. Cap., ii, 367 (*Purgosea punctata* Sweet, Hort. Brit., ed. 2, 223). *Cr. obovata* Haw. in Suppl. Pl. Succ., 17; DC., Prodr., iii, 387 (*Turgosea obovata* Haw., Rev. Succ., 16; *Purgosea obovata* Sweet, Hort. Brit., ed. 2, 223) is, according to a drawing by Haworth in the Kew collection, close to *Cr. ramuliflora* var. *stachyera*, but cannot be determined with certainty.

(*d*) *transvaalensis* Schonl. In this variety I unite some Transvaal forms

which can be fairly closely matched with a specimen with branched inflorescence from Somerset East collected by MacOwan, referred to var. (*c*), from which they differ chiefly by more elongated acute marginal papillae of the leaves (similar to those found in *Cr. setulosa*). The calyx is $\frac{4}{5}$ the length of corolla.

Wonderboom, near Pretoria, Mar., Mogg, 17205 (leaves hispid on the surfaces); Northern Transvaal, Ledoux, 50 (leaves glabrous on the surfaces).

(*e*) *pulchella* Harv. in Fl. Cap., ii, 344. Dwarf perennial, leaves subrotund or ovate, not more than 10 mm. long. Inflorescence subcapitate. Calyx about $\frac{2}{3}$ of corolla.

? Mrs. Barber, 850; Karkloof, 4000 ft., Apr., Wood, 4455 and 4498; Entumeni, Zululand, 1000–2000 ft., Mar., Wood, 2490; Rovelo Hills, Natal, 7000 ft., Mar., Sutherland (type in Herb. Kew).

I add a full description of a rather extreme form of this variety.

Herbacea perennis e basi ramosa, ramis erectis vel adscendentibus simplicibus foliatis rubris retrorse hirsutus. Folia inferne congesta sursum remota internodiis subaequilonga leviter connata late cordato-ovata obtusa carnosa infra convexa supra concava faciebus glabris marginibus retrorse papilloso-ciliatis. Inflorescentia terminalis pauciflora contracta subcapitata. Flores breviter pedicellati erecti. Sepala oblongo-lanceolata subcuspidata marginibus minutissime et irregulariter ciliatis, viridia vel apicem versus rubra. Petala alba oblongo-oblanceolata erecta ultra medium patentia dorso infra apicem minute mucronulata. Stamina sublibera filamentis subulatis antheris oblongis rubro-brunneis. Carpidia gracilia ovariis stilis sub aequilongis margine ventrali laevi. Stigmata minuta. Squamae minutissimae luteae.

Flowering branches 5–6 cm. long. Lower leaves about 8 mm. long and about 6 mm. broad, upper gradually smaller, uppermost about 5 mm. long. Sepals about 3·5 mm. long. Petals 6 mm. long. Stamens and carpels about 5 mm. long.

Rocky places, Inchanga Valley, Natal, Mar., Sim, 4238.

(*f*) *Bolusii* Schonl. 'Leaves oblong-lanceolate, retrorsely setose on both surfaces and on the margin, about 1·3 cm. long. Cymes capitate, sometimes arranged in corymbs. Calyx more than $\frac{2}{3}$ of corolla, more or less setose on back and margin.

Kei Road Station, 2300 ft., Feb., Bolus, 8905; Dohne, 3000 ft., Mar., Sim, 1223; top of Perie Mt., 4500 ft., Sim, 1769.

(*g*) *Simii* Schonl. Similar to (*e*), but leaves sometimes glabrous on the surfaces. Inflorescence capitate or subspicate-thyrsoid. Sepals glabrous or subglabrous.

Perie, 3000 ft., Jan., Sim, 1225; Ifzeli, 2000 ft., July, Sim, 1222; S. Johns, Aug., Sim, 2551.

The last two varieties form a transition between *Cr. ramuliflora* Link et Otto and *Cr. dregeana* Harv.

(*h*) *Rattrayi* Schonl. Leaves oblong subacute and narrowed at the base, up to 2 cm. long, frequently setose on the back along the median line up to or beyond the middle. Cymules few-flowered, sessile or pedunculate in a very short terminal thyrsus. Sepals about as long as petals, sparingly pilose on the back.

Hogsback, Rattray (a specimen from top of Dohne Hill, 5000 ft., Mar., Sim, 1768, comes close to it, but has narrower leaves which are covered with bristles all over).

(*i*) *Bewsii* Schonl. Leaves oblong, ovate or subrotund, subacute, glabrous or hispid on the surfaces, 1–2 cm. long. Inflorescence capitate or corymbose. Sepals about $\frac{2}{3}$ the length of corolla, ciliate on margin, glabrous on back or setose along the middle.

Qwen Spruit, Umgeni Valley, near Hilton College, 3000 ft., Bews, B (leaves glabrous), C (leaves hairy); Cala district, rocky slopes near Kokstad, 5000 ft., Tyson, 1333.

In concluding these remarks on *Cr. ramuliflora* I should like to add that this protean species will repay more intense study from live specimens. It evidently represents a number of species in the making.

118. **Cr. lasiantha** (E. Mey.) Harv. in Fl. Cap., ii, 344.

Winterhoeksberg, 2000–3000 ft., Drege in Herb. S.A. Mus.

Characterised by its trailing habit, small subrotund or broadly ovate leaves, calyx-lobes covered with white bristles and small flowers in dense fascicles.

119. **Cr. Meyeri** Harv. in Fl. Cap., ii, 344.

Cr. capitellata E. Mey. vix Linn. (ex Harvey).

Between the Umsamculo and Omcomas, Drege. Not seen by me.

Characterised by oblong lanceolate leaves ($1\frac{1}{4}$–$1\frac{1}{2}$ in. long), longer than the internodes. Flowers white, 2–3 lines long. Calyx-lobes $\frac{1}{2}$ as long as corolla, rough on edge and keel. I have not seen a type of this species. It is probably identical with *Cr. ramuliflora* Link et Otto, (*a*) *typica* Schonl.

120. **Cr. Peglerae** Schonl. in Rec. Albany Mus., ii (1907), 142.

Kentani, 1000 ft., Mar., Pegler, 1181.

Characterised by leaves ovate or ovate-lanceolate acute c. 1·8 cm. long, about as long or longer than the internodes. Calyx-lobes subglabrous, nearly $\frac{2}{3}$ the length of the petals (which are 5–5·5 mm. long). The papillae on the margin of the leaves and on the stem are thicker and shorter than in allied species and usually blunt.

[*Cr. aloides* Haw. in Rev. Pl. Succ. (1831). I mention this here because Haworth seems to think that it is closely allied to *Cr. punctata* Haw., from which it differs by hispid stem and leaves, and to *Cr. obovata*, from which

it differs by smaller size and form of leaves, but it can hardly be *Cr. alooides* (Solander) in Ait. Hort. Kew., i, 394, to which he refers his specimens. The latter seems to belong to the *Rosularis* group.]

121. **Cr. rubescens** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 363.

Summit of Mont aux Sources, Basutoland, 9500 ft., Flanagan, 1834.

Var. *laxa* Schonl. Laxly branched, chiefly from the base, up to 22 cm. high. Basal leaves up to 2·5 cm. long, the pairs on the branches remote. Flowers in lax terminal corymbs.

Majuba Nek, Sterkspruit, Herschel district, Feb., Hepburn, 334; Ingeli Mt., Griqualand East, 6000 ft., Tyson, 1285.

Var. *intermedia* Schonl. About 12 cm. high, more compact than var. *laxa* and approaching the type in appearance. Leaves often minutely cuspidate.

Drakensberg, summit of Doodmans Krantz, Barkly East district, c. 9650 ft., Mar., Galpin, 6625; Barkly Pass, 8000 ft., Mar., Rattray, 2135, 2136; slopes of Drakensberg Mts., Feb., Hepburn, 296.

Setulosa group.

122. **Cr. sedifolia** N. E. Br. in Gard. Chron. (Dec. 1902), 429, 430.

South Africa (locality unknown). Type in Herb. Kew.

From the description the following notes are taken: Only 1–2 in. high. Leaves in radical tufts and 3–4 pairs scattered on the flowering stem, $\frac{3}{4}$–$3\frac{1}{4}$ lines long and nearly as thick, subacute, minutely mucronate, glabrous except for the sparingly ciliate margins, with a row of 3–5 red spots along each margin.

123. **Cr. Cooperi** Regel in Gartenflora, 1874, 36, t. 876; Schumann in Sukkulenten (1892), fig. 53.

Cr. Bolusii Hook. f. in Bot. Mag., t. 6194.

Albert district, Cooper, 676, in Herb. Kew; amongst rocks, mountain-sides, Graaff Reinet, 4000 ft., Apr., Bolus, 423; Cradock Mts., Sim; Boschberg, 4500 ft., MacOwan, 1531. I have seen live specimens of this species collected by Dinter (No. 27) at Auros, S.W. Protectorate, and named by him *Cr. aurosensis* Dtr. MS. It differs from the type only in unimportant details. Schumann's figure shows this species growing with elongated branches in a hanging basket. Burtt-Davy records it from several places in the Transvaal.

124. **Cr. Schmidtii** Regel in Gartenflora (1886), 345, t. 1225.

Cr. impressa N. E. Br. in Gard. Chron. (1879), ii, No. 328 (non D. Dietr. in Syn. Pl., ii, 1031).

Regel describes and figures the sepals as linear lanceolate. In specimens

grown at Kew they are oblong lanceolate, very shortly aristate, while in Dieterlen, 1081, they are slightly broader. Specimens from Hanover, Cape Province, are somewhat taller and more robust in all parts than the type. In these the inflorescence is thyrsoid or paniculate, but no sharp line can be drawn between them (which I erroneously referred to *Cr. Cooperi* in Rec. Albany Mus., ii, 144) and the type.

Heilbron, O.F.S., Jan., Williams, 25; Likhoele, Mafeteng, Basutoland, Feb., Dieterlen, 1081; among stones on the lower randts, Bangor Farm, Middelburg district, Cape, frequent, c. 4000 ft., Bolus, 14124 (this is only about 5 cm. high, with almost sessile, multiflowered, paniculate inflorescence and ovate-acute, rosulate leaves about 2 cm. long and about 1·3 cm. broad, with marginal cilia somewhat longer than in the type); Hanover, Cape, Purcell (flowered in Grahamstown, Feb. 1906); Eagle's nest, Bloemfontein, Mar., Potts (petals white, sepals and stem red, while in the type petals white at base, otherwise red); Richmond (Natal), Natal Bot. Gard., 1323/14 (similar to Bolus, 14124, but with narrower leaves).

125. **Cr. setulosa** Harv. in Fl. Cap., ii, 347.

This is one of the most puzzling species amongst all South African Crassulas. Already Harvey, who only knew it from one locality (Doornkop, near Krugersdorp), pointed out that the leaves may be rigidly hispid on one or both surfaces or may be glabrous, but in my opinion it varies in many other respects. There are several "species" described, which are close to it, some of which certainly cannot be satisfactorily separated, *Cr. deminuta* Diels in Engl. Bot. Jahrb., xxxix (1907), 467. The type was found by Wilms (No. 515) at the Large Waterfall in the Lydenburg district. The author says it is allied to *Cr. orbicularis*, while Engler in Engl. Bot. Jahrb., xxxix (1907), 466, says it is very close to *Cr. inchangensis* Engl., which he considers to be close to *Cr. setulosa* Harv., but which he now refers to *Cr. stachyera*. Burtt-Davy places it with *Cr. compacta* and *Cr. nodulosa*, which cannot be justified at all. Wilms, No. 513, is according to the author a lax ("schlaff") variety of *Cr. deminuta*.

Cr. Scheppigiana Diels in Engl. Bot. Jahrb., xxxix (1907), 465, is certainly only a form of *Cr. setulosa*. Some years ago I examined a type (Wilms, 519, from kloof near Coldstream, Transvaal). Another type is Wilms, 514, from Paardeplaats, Lydenburg district.

Then there are *Cr. curta* N. E. Br. and *Cr. Schlechteri* Schonl., to which reference will be made presently.

I have tentatively divided the specimens, which I have before me, into a number of varieties, but I am quite ready to admit that if they are better known in the live state (especially the last ones) it may be advisable to treat them as separate species.

(*a*) *lanceolata* Schonl. Branched from the base. Cauline leaves

lanceolate or ovate-lanceolate. Calyx-lobes ciliate, $\frac{2}{3}$ the length of the corolla.

Doornkop, Z. 650; Witwatersrand, Apr., Hutton, 999.

(*b*) *ovata* Schonl. Cauline leaves ovate or subovate, obtuse or acute. Calyx as in (*a*).

In moist ground in cleft of rock on mountain-sides, Eland's Hoek, Aliwal North, 4700 ft., Apr.–May, Bolus, 10533 (flowers whitish pink, approaches *Cr. Schmidtii* Reg.). Barkly Pass, 8000 ft., Mar., Rattray, 2135; Krugersdorp, Jan., Jenkins in Herb. Transv. Mus., 10034; Majuba, Natal, Mar., Rogers, 125, 610; to this variety may also be referred a form with very closely set subimbricate cauline leaves represented by Galpin, 1386, Jeppestown, Johannesburg, 5900 ft., Feb., and another form with closely set cauline leaves which are spreading or even slightly recurved, represented by Leendertz, 1101, Pretoria, Feb. Gilfillan in Herb. Galpin, 7273, from Witbank Station, Middelburg, Transvaal, Jan., connects (*a*) and (*b*), the calyx-lobes are, however, only slightly scabrous on the margin, and the marginal papillae of the leaves are shorter than usual and subobtuse.

(*c*) *ramosa* Schonl. Repeatedly branched below the inflorescence in a pseudo-dichotomous manner. Cauline leaves ovate. Calyx as in (*a*) and (*b*).

Magalisberg at the Crocodile River, Feb., Burtt-Davy (cultivated in garden, description in Rec. Albany Mus., ii, 144); Dasport, Feb., Leendertz, 582; stony hills near Pretoria, c. 4800 ft., Feb., Bolus, 10835; Modderfontein, Witwatersrand, Jan., Rogers, 14126 (upper leaves lanceolate).

(*d*) *robusta* Schonl. Plants larger and stouter than in any other varieties (up to 20 cm. high). Cauline leaves oblong-lanceolate, acute or oblanceolate, obtuse, the largest $1\frac{1}{2}$ cm. long. Internodes as long or shorter than the cauline leaves. Calyx $\frac{2}{3}$ of the corolla.

Johannesberg, stony kopje, Feb., Burtt-Davy, 3067; *ibid.*, Mar., Pym, 972; *ibid.*, Mar., Moss, 10500.

(*e*) *curta* (N. E. Br.) Schonl. (*Cr. curta* N. E. Br. in Kew Bull., 1895, 144, and var. *rubra* N. E. Br.; *Cr. Schlechteri* Schonl. in Journ. Linn. Soc. (Bot.), xxxi (1897), 551).

Into this variety I place a number of dwarf forms (chiefly from the Drakensberg Mts.), rarely more than 7 cm. high. The leaves are usually lanceolate, oblanceolate, or ovate. The pairs of cauline leaves are usually separated by internodes equal to or exceeding the length of the cauline leaves, which are usually about 5 mm. long. The length of the calyx-lobes usually nearly equals the length of the petals, but sometimes they are only $\frac{2}{3}$, frequently even only $\frac{1}{2}$ their length.

The types of *Cr. curta* are Evans, 408, from the Tabamhlope Mt., 6000–7000 ft., and Wood, 4592, from the Amahqua Mt., 6000–7000 ft.,

Apr. The type of *Cr. Schlechteri* is Schlechter, 6916, from Van Reenen, 5500 ft., Mar.

In both of these the calyx is nearly equal to the corolla. With these we can associate: Zuurberg, Griqualand East, 5500 ft., Feb., Tyson, 1717; Himeville, Dec., Bews, 1.

We can further associate with one another a number of specimens in which the sepals are ½ or rarely up to ⅔ the length of the petals and which otherwise resemble *Cr. curta* N. E. Br. very closely, *e.g.*:

Doodmans Krans, Drakensberg, c. 8900 ft., Mar., Galpin, 6621, 6623; Barkly Pass, 8000 ft., Rattray, 2131, 2132, 2134; Tugela Valley, Mont aux Sources, 6000 ft., July, Sim, 19022; krans on river bank, Mt. Hope Farm, Upper Zwartkei, 5000 ft., Mar., Galpin, 2646; ? on rocks, mountain-sides, Bowkers Park, 4000 ft., Mar., Galpin, 2064; Mt. Fletcher, Feb., Sim; Culvers, Weenen, 6000 ft., Feb., Rogers, 27993.

(*f*) *basutica* Schonl. Into this variety I place a number of forms, some of which come very close to *Cr. Schmidtii* Reg. They have on the whole broader leaves than this species and longer marginal cilia. The leaves are always hispid on both surfaces, the cauline ones are lanceolate, ovate lanceolate, or obovate. The inflorescence is cymose-corymbose, rarely thyrsoid. The calyx-lobes are ⅓ of the corolla.

Leribe, Feb., Mar., Dieterlen, 252*c*, 877, 877*a*, 969.

? (*g*) *Jenkensii* Schonl. Only one specimen is available, which may represent a distinct species. It is almost 6 cm. high. From a woody base there arise two branches which divide again into two. All leaves are lanceolate acute. The basal ones are crowded, about 1½ cm. long, but there is no distinct rosette. In the uppermost portions of the branches the leaves are 3·2 mm. long, with internodes of about the same length. The leaves are glabrous on the back, with margin glabrous except that both radical and cauline leaves are provided on each side with a few setose cilia. The stem is retrorsely papillose-hispid. The inflorescences are terminal capitate, few-flowered. The calyx is equal to the corolla in length, the lobes bear a few cilia on the margin.

Krugersdorp, Jan., T. J. Jenkins (Trans. Mus. Herb., 10369).

(*Cr. montana* Thunb. in Nova Acta, vi (1778), 329, 332, Prodr., 55, Fl. Cap., ed. Schultes, 285; L. f., Suppl., 189.

Britten and Bak. f. say in Journ. of Bot., xxxv, 481, with reference to this species: In herbarium from Masson, written up as Thunberg's plant by Dryander. Unknown to Harvey. Caespitose. Leaves radical, ovate, acute, thin, concave, ciliate on the edge, bearing about ¼ in. from the head of flowers two connate, ciliate bracts. Flowers capitately congested. "In summo monte Bockland" (Thunberg). Closely allied to *C. Cooperi* Reg. and *C. curta* N. E. Br.

I have seen Thunberg's type of this species, which is preserved in his herbarium at Upsala. It is also represented in Herb. Linnaeus, London (No. 34). I agree with Britten and Baker's conclusion as to its position, but in the group to which it belongs specific differences are largely destroyed when the plants are dried, and I do not venture to decide whether it is distinct.

126. **Cr. barklyana** Schonl. in Rec. Albany Mus., ii (1907), 147.

Damp places on Ben McDhui, Barkly East district, c. 9450 ft., Mar., Galpin, 6626.

127. **Cr. densa** N. E. Br. in Kew Bull. (1912), 275.

Collected during the Percy Sladen Expedition to the Orange River, Pearson, 6151. Type in Herb. Kew.

The plant is $1\frac{3}{4}$–2 in. high, densely branched, with subtrigonous, minutely white-subtuberculate leaves, puberulous peduncle and calyx. Peduncle terminal, flowers sessile forming a cymose capitulum. Carpels about $\frac{1}{2}$ the length of the stamens. Stigma sessile. I suggest that it should be placed near *Cr. sedifolia* (but leaves *not ciliate, distinctly connate-perfoliate*). The author could not suggest any close affinity with other species.

SEDIFLORA group.

128. **Cr. sediflora** Endl. in Walp. Rep., ii, 254 ; Harv. in Fl. Cap., ii, 346.

Pyrgosea sediflora E. et Z. in Enum., No. 1909.

Katberg, above the forests (thus over 5000 ft.) in damp places, Mar., E. and Z. 1909 ; Windvogelberg, near Cathcart, Feb. '99, Sim.

Var. *laxifoliosa* Schonl. Flowers and inflorescence as in the type. Stem and leaves sparsely pilose. Lower internodes usually about as long as the leaves (in the type $\frac{1}{2}$ as long), upper longer. Lower leaves up to 2·5 cm. long and 0·8 cm. broad, acute, attenuate towards the base, upper gradually smaller and narrower.

Ifzeli, 1500 ft., Jan., Sim, 1270 ; Brownlee Station, near Kingwilliamstown, 1500 ft., June, Sim, 1224 ; river-bed in forest kloof, Mt. Coke, Apr., Galpin, 7844.

Pyrgosea sediflora E. et Z. was placed by the authors near *Cr. turrita*, which is quite unwarranted and misleading.

129. **Cr. amatolica** Schonl. n. sp.

Suffruticosa caespitosa. Caulis parce ramosus ad 40 cm. longus, c. 1·5 mm. diam., decumbens vel adscendens basi sublignosus efoliatus annulatus teres subflexuosus, ramis subflexuosis primum puberulis deinde glabris suberectis dense foliatis herbaceis teretibus, internodiis subaequalibus c. 3 mm. longis. Folia opposita basi connata imbricata subplana ovato-lanceolata acuta utrinque glabra ad margines brevissime papilloso-ciliata vel scabrida

5–10 mm. longa, 2·5–5 mm. lata. Inflorescentia terminalis cymoso-subcapitata sessilis pauciflora, bracteis foliis similibus sed brevioribus floribus breviter pedicellatis. Tubus calycis c. $\frac{3}{4}$ mm. longus, lobi lanceolati c. $2\frac{1}{4}$ mm. longi. Corolla alba, tubo c. $\frac{1}{2}$ mm. longa, segmentis lineari-lanceolatis obtusis erectis emucronatis c. $2\frac{1}{4}$ mm. longis. Filamenta c. $1\frac{1}{4}$ mm. longa, antherae late oblongae. Carpidia (immatura ?) c. $1\frac{1}{2}$ mm. longa, ovariis oblique ovatis 2-3-ovulatis apice in stilum brevem subulatum attenuatis. Squamae minutae obcuneatae.

Cata Ridge, Amatola Mts., amongst grass and rocks near swampy stream, 6000 ft., Jan., Dyer, 356. Type in Herb. Albany Mus.

Mr. R. A. Dyer, who discovered this species and dissected it for me, supplied the following additional notes : Plant found in dense tufts about a foot high, the flowers only last 24–48 hours, the stem near the inflorescence is purplish, as also the base of the calyx-tube, the calyx-segments are light green, thin, glabrous. Petals white, thin. Filaments attached to the corolla tube, anthers flesh-coloured. Apex of style with no distinct stigma, purplish.

130. **Cr. Flanagani** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 362.

Type in Herb. Albany Mus. East London, amongst rocks, Flanagan, 1272, Rattray, 108, Galpin, 3160, 5676 ; Kingwilliamstown ; Kentani, Apr., 800 ft., Pegler, 1336 ; Fields Hill, Natal ; Sydenham, Natal, c. 200–300 ft., Wood, 12777. This species leads up to *Cr. corymbulosa.*

131. **Cr. tenuifolia** Schonl. in Bull. de l'herb. Boiss., v, 860.

Type in Herb. Albany Mus. Natal, in rocky dampish places, 1800–3000 ft., Apr.–May, Wood, 597, 1840, 4462, Sim, 15002 ; Clydesdale, Griqualand East, 2500 ft., Feb., Tyson, 2141.

Quadrangularis group.

132. **Cr. quadrangularis** Schonl. in Rec. Albany Mus., i, 57. Canon in General and Physiological Features of the Vegetation of the more arid portions of South Africa (1924), pl. 10.

Laingsburg, Marloth, 2512 (flowered in Grahamstown, Oct. 1902 ; type in Herb. Albany Mus.) ; Matjesfontein, Marloth, 10853.

There is an unfortunate mistake in the original description. It should read " sepals about 2 mm. long, petals about 4 mm. long."

This seems to be the same plant which is erroneously named *Cr. hemisphaerica* Thunb. in Herb. Drege at Kew.

133. **Cr. socialis** Schonl. n. sp.

Herbacea perennis caespitosa. Radices fibrosi. Caulis suberectus elongatus teres 4–7 cm. longus internodiis albis superne roseo-tinctis 1–5 cm.

longis inferne ramosus. Folia opposita 10–12, superiora subrosulata, connata carnosa, inferiora ambitu oblongo-ovata acuta, superiora ovata acuta, omnia intus concava, extus convexa, superiora subcomplicata, faciebus glabris margine retrorsum ciliata, inferiora c. 1 cm. longa, superiora c. 0·75 cm. longa. Scapus terminalis gracillimus subflexuous bracteis vacuis instructus, apice inflorescentia subcapitata 2–3 furcata 1–2 cm., diam. c. 5 mm. alta. Flores subsessiles. Sepala pallide viridia dorso apicem versus subumbonata basi connata, lobis ovatis subacutis 1–1¼ mm. longis. Petala suberecta, subnavicularia, oblongo-ovata, basi subconnata, infra apicem dorso mucronulata, alba, 2–2½ mm. longa. Stamina quam petala breviora, filamentis subulatis, antheris latioribus quam longis. Carpidia 1½ mm. longa, ovariis oblique ovatis, stilis brevissimis horizontalibus, stigmatis terminalibus. Squamae membranaceae loreae c. ⅜ mm. longae.

Middledrift area, Kingwilliamstown division, at the junction of the Chumie and Keiskama rivers, on ledges and in crevices of krantz, common, forming dense little clumps, Sept., Crampton, 18. Type in Herb. Albany Mus.

The stems grow fairly straight up, branches are formed near the base, which separate easily and become rooted; thus a dense mass of plants is formed. The horizontal very short style is unique in the genus.

Amongst other peculiarities are the strap-shaped squamae, about ⅓ the length of the ovaries, and the subrosulate upper leaves are noteworthy. The species when grown in Grahamstown in the open during a rather dry year altered somewhat; the stems were thin, stunted. The leaves were slightly plicate, and the upper formed a 4-angled rosette as in *Cr. quadrangularis*.

134. **Cr. Mossii** Schonl. n. sp.

Herbacea perennis. Caulis brevis foliis subrosularibus erecto-patentibus carnosis subplanis sessilibus obovatis obtusis vel subacutis interdum plicatis, faciebus glaucis glabris, ad margines breviter retrorsum ciliatis, ciliis albis. Inflorescentia breviter thyrsoidea pedunculata, cymulis c. 8 subcapitatis, inferioribus non sessilibus, superioribus sessilibus, bracteis foliis similibus sed brevioribus sursum gradatim decrescentibus. Sepala sublibera lanceolata obtusa ad margines minute papillosa c. 2·5 mm. longa. Petala alba erecta versus apicem leviter patentia, sublorea apicem versus leviter ampliata, dorso infra apicem minute mucronulata, c. 5 mm. longa. Stamina 4 mm. longa, filamentis albis sublinearibus apice contractis, antheris oblongo-ovatis pallide luteis. Carpidia 3 mm. longa, ovariis oblique oblongis c. 2·5 mm. longis, stylis c. ½ mm. longis, stigmatis parvis capitatis. Squamae minutae carnosae latiores quam longae apice rotundatae.

Farm "The Downs," Drakensberg, collected by the Rev. F. A. Rogers, and grown by Professor Moss in his greenhouse at Johannesburg. Type in Herb. Albany Mus. Received Oct. 1918. I noted at the time that this

species is much more sharply proterandrous than most species of *Crassula*. The largest leaf was 4·6 cm. long, 3 cm. broad, the younger are much smaller.

This species may only be a form of the following.

135. **Cr. compacta** Schonl. in Journ. Linn. Soc. (Bot.), xxxi (1897), 550. *Cr. massonioides* Diels in Engl. Bot. Jahrb., 1907.

Type in Herb. Albany Mus. Stony ground, Saddleback Mt., near Barberton, 5000–5300 ft., Sept.–Oct., Galpin, 1092; Vaal River, near Cloete, Transvaal, Oct., Wilms, 526 (type of *Cr. massonioides* Diels).

ROSULARIS group (*Rosulares* Harv. in Fl. Cap., ii, 334).

136. **Cr. rosularis** Haw., Rev. Pl. Succ. (1831), 3; DC., Prodr., iii, 389; E. et Z., Enum., No. 1901; Harv. in Fl. Cap., ii, 349; Wood, Natal Plants, iii, t. 266; Pole-Evans, Plants of South Africa, t. 167 (non Bot. Mag., t. 5393).

Generally found in rocky ground (frequently in slight shade), Bitou River, near bridge, 10 ft., Oct., Fourcade, 1494 (flowers white); Redhouse, Aug., Paterson; Uitenhage division, etc., E. and Z. 1901; Graaff Reinet, 2500 ft., Aug., Bolus, 484; Alicedale, June, Cruden, 265 and 8*a*; very common in the neighbourhood of Grahamstown, Sept.–Nov. (MacOwan, 2290, Drege, 6897*a*); Middledrift, July, Salisbury, 341; Perie, Godfrey, 87; Bazija, 2000–2500 ft., July, Baur, 654; Inanda, Wood, 600 ft.; near Durban, July, Wood, 6282; Umbombolo Range, 3600 ft., Sept., Galpin, 2147.

All these are more or less typical, but in many places one finds with them specimens with obovate spathulate leaves which are closely imbricate and shorter than usual. These forms more or less retain their characteristics under cultivation, and they are, therefore, separately enumerated.

Great Brak River, 2500 ft., Oct., Schlechter, 5739; Eastford, Knysna, 20 ft., Sept., Phillips, 111; Zwartkops River and near Phillipstown (Kat River), E. and Z. 1901; common near Grahamstown; Queenstown, 4000 ft., Aug., Galpin, 1354; Komgha, July, 1800 ft., Flanagan, 1274; Windvogelberg, near Cathcart, 3500–3800 ft., Oct., Baur, 906; Umbombolo Range, Galpin, 2147, p. pte.

There are also forms which emit distinct runners, as in *Cr. orbicularis*. These can always be recognised as belonging to *Cr. rosularis* by their petals being suberect (gradually and very slightly recurved towards the apex) and evenly coloured.

Redhouse, Nov., Paterson, 381; East London, Aug., Rattray, 109.

The following species is not well defined by technical characters, but is regarded by local botanists as quite distinct. The petals are white, the

flowers more congested in the cymules, the styles are shorter and recurved. The anthers and styles are red (anthers yellow, styles white in *Cr. rosularis*).

137. **Cr. intermedia** Schonl. n. sp.

Herba perennis rhizomate brevi vel elongato basi ramoso, ramis subsessilibus. Folia opposita distincta, rosularia patentia vel adscendentia basi imbricantia carnoso-coriacea subplana dorso convexiuscula, oblongo-cuneata, ovata vel obovata basi cuneata, faciebus viridibus glabris, ad margines albo-ciliata, ciliis patentibus, inferiora 4–5 cm. longa, 3–3·5 cm. lata, superiora gradatim breviora. Inflorescentia cymoso-paniculata cymulis congestis c. $\frac{1}{2}$–$\frac{3}{4}$ diam., bracteis inferioribus foliis similibus sed multo minoribus superioribus parvis lanceolatis, floribus subsessilibus. Calycis tubus vix 1 mm. altus, lobi subovati margine ciliati. Corolla alba, petalis navicularibus basi breviter connatis suberectis oblongo-linearibus infra apicem dorso mucronulatis, mucrone parvo obtuso, $3\frac{1}{4}$–$3\frac{3}{4}$ mm. longis. Stamina quam petala breviora, filamentis subulatis, antheris parvis late oblongis rubris. Carpidia $1\frac{1}{4}$–$1\frac{1}{2}$ mm. longa, ovariis oblique oblongis, stilis subulatis recurvis vix $\frac{1}{2}$ mm. longis, stigmatis parvis capitatis. Squamae obcuneatae apice subtruncatae leviter emarginatae c. $\frac{1}{2}$ mm. longae.

In rocky, shady places near Grahamstown, c. 2000 ft., Aug.–Oct., Rogers (Aug. 1908), Dyer, 160; Booma Pass, near Keiskama Hoek, Aug., Crampton, 5. Type in Herb. Albany Mus.

Slight irregularities in floral structure are not uncommon in many species of *Crassula*. A specimen of this species grown at Rhodes University College (as far as practicable under natural conditions, though perhaps with more light than in nature) had no flowers with normal structure, though they all had 5 sepals and 5 petals. Occasionally a petal showed 2 mucros at the top (beginning of splitting ?). There were usually 10 stamens, one flower showed actually the typical formula of the genus *Sedum* (which is absent from South Africa): K 5, C 5, A 5 + 5, G 5. A few other observed combinations were: 10 stamens, 6 carpels; 8 st., 8 carp.; 7 st., 7 carp.

138. **Cr. orbicularis** L., Sp. Pl., 283, Mant., 361, Syst. Veg., xiv, 306, Hort. Cliff., 496; Dillenius, Hort. Elth., t. 100, fig. 18; N. L. Burmann, Prodr., 8; Thunberg, Prodr., 57, Fl. Cap., ed. Schultes, 291; Houttuyn Linn., Pfl. Syst., 6, 286; Willd., Sp. Pl., i, 1563; DC., Pl. Gr., t. 43, Prodr., iii, 389; Haw., Syn. Pl. Succ., 56, Rev. Pl. Succ.; E. et Z., Enum., No. 1900; Harv. in Fl. Cap., ii, 349.

Cr. sedioides Mill., Dict., ed. 8, No. 9.

Cr. hemisphaerica E. Mey. in Herb. Drege (ex Harvey).

Rocky karroid hills near the Gauritz River, Swellendam, alt. II, Dec., E. and Z. 1900; Nieuwe veld, near Beaufort West, Drege (teste Harvey); Belvedere, Knysna, Rehmann, 412; sine loco, Bolus, 640; Oudtshoorn, Miss Taylor (flowered in Grahamstown, Sept.–Oct. 1907).

DC., Pl. Gr., t. 43, is very poor. De Candolle states in the accompanying description that the petals and calyx are subequal, which is clearly a mistake.—It can easily be distinguished from *Cr. rosularis* by its petals being distinctly recurved from below the middle. They are white at the base, but are reddish towards the apex. The squamae are thin, white, and spathulate, about $\frac{1}{4}$ the length of the carpels. The possession of runners is occasionally shared with *Cr. rosularis*.—(Bot. Mag., t. 5393, is a puzzle to me. It was published as *Cr. rosularis*, but neither agrees with this species nor with *Cr. orbicularis*, with which it shares the shape of the corolla.)

Minor characters of *Cr. orbicularis* which cannot be seen in dried specimens : Sepals and bracts green with reddish margin, peduncle, bracts and sepals minutely papillose. The anthers are yellowish, the stigmata red.

This species is well defined by the specimens in Herb. Sherard at Oxford, on which Dillenius' figure is based. Specimens bearing this name in Herb. Thunberg resemble more *Cr. rosularis* in habit but, as far as can be judged without dissection, the flowers are those of *Cr. orbicularis*. Rightly named specimens are also in Herb. Lamarck. Specimens named *Cr. orbicularis* in Herb. Linnaeus, London, are numbered 27–29.

No. 27 is quite a different species. It belongs to sect. *Globulea*, but cannot be determined with any degree of certainty.

No. 28 is probably rightly named, but too scrappy to make sure.

No. 29 is certainly not *Cr. orbicularis*, but again too scrappy for exact determination.

139. **Cr. Gillii** Schonl. in Rec. Albany Mus., ii (1907), 145.

In rocky places near the Klein Vischrivier, Oct.–Nov., 3000 ft., MacOwan, 1586.

This has been distributed by MacOwan as *Cr. orbicularis* L. It is without runners, has an inflorescence which is capitate or subcorymbose composed of a few capitate cymules. It comes close to *Cr. rosularis*, from the broad-leaved forms of which, apart from the inflorescence, it is distinguished by much denser cilia on the margin and narrower calyx-lobes. Leipoldt, 525, from near Wupperthal, 3000 ft., may have to be referred to this species.

(*Cr. alooides* (Soland.) in Ait. Hort. Kew., i, 394, No. 17 ; Britten et Bak. in Journ. of Bot., xxxv (1897), 482.

There are specimens preserved in the British Museum, which I have not seen.

The herbarium specimens were, according to Britten and Bak. f., named by Solander *Cr. alooides* and subsequently doubtfully referred by him to *Cr. orbicularis*, but judging from the following characters it seems to be distinct : "Sepals glabrous, about 1 line long, petals about three times longer than the calyx" [this would mean that the flowers are much larger than in *Cr. orbicularis*] "white, virescent below."

The question, whether this is *Cr. aloides* Haw., should be re-examined, as this is hispid on the stem and leaves.)

TURRITA group (*Thyrsoideae* Harv. in Fl. Cap., ii, 334).

140. **Cr. turrita** Thunb. in Nova Acta Nat. Cur., vi (1778), 336, Prodr., 55, Fl. Cap., ed. Schultes, 285; Linn. f., Suppl., 189; Linn., Syst. Veg., ed. 14, 307; Willd., Sp. Pl., i, 1562; Jacq., Hort. Schoenbr., t. 52; DC., Prodr., iii, 388; Harv. in Fl. Cap., ii, 348.

Pyrgosea turrita E. et Z. in Enum., No. 1905; Sweet, Hort. Brit., ii, 223; *Cr. paniculata* D. Dietr., Syn. Pl., ii, 1031; *Globulea paniculata* Haw. in Herb. Berol.

We are a bit in the dark as to whether the plant which we call *Cr. turrita* Thunb. is really this species, as there is no specimen preserved in Herb. Thunberg and he had never seen it in flower. It is, however, likely that we are correct in taking Zeyher's specimens to be typical.

Oudtshoorn (flowered in Grahamstown), Mar., Taylor; Duine veld, Slang River, Humansdorp division, 50 ft., Mar., Fourcade, 2147 (in one specimen inflorescence with numerous lateral branches in lower part); Redhouse, Oct., Paterson, 250 (branched like the one just mentioned =*Globulea paniculata* in Herb. Berol.); karroid places near the Zwartkops River, 1st alt., Jan., Z. 2543 (=E. 1041), ? Rogers, 132; Bruintjeshoogde, 3000 ft., Nov.-Dec., MacOwan, 1244 (stem very slightly hairy, sepals sparingly and finely ciliate); not uncommon near Grahamstown (sometimes with slightly hairy stem); Belmont Valley, near Grahamstown, Jan., Salisbury, 355 (leaves copiously pitted on the upper surface, the older ones copiously rufo-punctate on the lower surface, inflorescence branched in lower part); Keiskama Hoek, Crampton, 92 (leaves as in Salisbury, 355); Ripplemead, Kabousie, Dec., Hutton, 504 (oldest and largest leaves obovate obtuse, inflorescence with one elongated branch in lower part); East London, Apr., Rattray, 27, 808 (one specimen with very irregular short branches of the inflorescence); Kentani, Oct., Pegler, 2073 (leaves blunt, inflorescence up to 38 cm. long), 1312 (leaves up to 9 cm. long and 4·5 cm. broad, obovate cuneate); grassy hills near Komgha, 2000 ft., Nov., Flanagan, 1101 (leaves obovate-cuneate, acute or subacute); Likhoele, Basutoland, Dieterlen, 1080.

The synonymy of this species is very difficult and has not been quite satisfactorily cleared up. However, there is no doubt that *Cr. paniculata* D. Dietr. cannot be separated from it.

141. **Cr. subbifaria** Schonl. n. sp.

Herbacea. Folia succulentia dense imbricata sessilia opposita oblique subdisticha oblongo-lanceolata acuta faciebus glabris ad margines retrorso-papilloso-ciliata, ciliis albis, inferiora patentia c. 3 cm. longa, superiora

gradatim breviora. Inflorescentiae thyrsoideae terminales et axillares, bracteis oppositis folia reducta simulantibus sed ovatis acutis numerosis inferne vacuis superne verticilliferis, verticillis sessilibus paucifloris. Calycis lobi oblongo-ovati acuti ad margines minute ciliati, $1\frac{1}{4}$–$1\frac{1}{2}$ mm. longi. Corollae lobi subliberi late lineares apice rotundati, infra apicem dorso mucronulati, mucrone parvo subovoideo, $2\frac{3}{4}$–3 mm. longi. Stamina quam petala paullo breviora, filamentis subulatis, antheris late oblongis. Carpidia parva, c. $1\frac{3}{4}$ mm. longa, ovariis oblique ovatis margine centrali carinato et minutissime ciliato, stigmatis subsessilibus subdorsalibus. Squamae membranaceae c. $\frac{1}{3}$ longitudine ovariorum, obcuneatae apice rotundatae et leviter emarginatae.

Steytlerville, Mar., Mrs. T. V. Paterson. Type in Herb. Albany Mus. Mrs. Paterson sent with this specimen some fragments of the inflorescence of a *Crassula* which is evidently closely allied to *Cr. subbifaria.*

Unfortunately I cannot give a full description and therefore prefer not to give it a name. It shows the following distinguishing features: The inflorescence is richly branched in the upper portion. The petals are slightly smaller than in the preceding one and subspathulate. The carpels bear a distinct, though short style, and the stigmata are small.

142. **Cr. inamoena** N. E. Br. in Kew Bull., 1912, 275.

Collected during the Percy Sladen Memorial Expedition to the Orange River in 1910, Pearson, 5486. Unfortunately only a single leaf is preserved in Herb. Kew.

143. **Cr. albanensis** Schonl. in Rec. Albany Mus., i (1903), 55.

Common near Grahamstown, amongst coarse grass, c. 2000 ft., Oct., Schonland, 616, 1676, Daly and Sole, 335. Type in Herb. Albany Mus. This comes close to the sect. *Globulea*, but has the petals of *Cr. turrita.*

144. **Cr. nodulosa** Schonl. in Rec. Albany Mus., i (1903), 56. Type in Herb. Albany Mus.

Cr. enantiophylla Bak. f. in Bull. de l'herb. Boiss., iii (1903), 816.

Cr. pectinata Conrath in Kew Bull., 1914, 247 (Herb. Kew).—Judging from the description of *Cr. Mariae* R. Hamet in Bull. de l'herb. Boiss., 2 ième série, viii (1908), 717, this species has to be sunk in *Cr. nodulosa.* It was found by Junod in Mozambique.

Niekerkshoep (flowered in Kimberley), Oct., Vermeulen; Warrenton, Apr., Adams, 28; Kos, Bechuanaland, Marloth, 1043; Bloemfontein, Feb., Potts, 392 (with several thyrsi at the end of the stem); Modderfontein, Conrath, 287, in Herb. Kew; near Geldenhuis mine, Johannesburg, 6000 ft., Jan., Galpin, 1460 (one thyrsus branched at the base); Pretoria Kopjes, Dec., Leendertz, 474; 24-Rivers, Waterberg division, Transvaal, Rogers, 23615; Houtbosch, c. 4100–4500 ft., Feb., Bolus, 10927; Houtbosch, Rehmann, 6372 (type of *Cr. enantiophylla* Bak. f.).

Bak. f. points out that his *Cr. enantiophylla* would have been placed by Haworth in his genus *Turgosea* or, as he afterwards called it, *Purgosea* (see Phil. Mag., 1828, p. 184). To this he referred, amongst others, *Cr. tomentosa* L. It is interesting to note that after the description of *Cr. elata* N. E. Br. in Kew Bull., 1909, 110, from the neighbourhood of Palapye, the author states that it is allied to *Cr. tomentosa* Thunb. It is close to *Cr. nodulosa*, but has subtomentose leaves. It may be said to be allied to *Cr. tomentosa* Thunb., but only in so far as the whole *Turrita* group may be said to lead up to *Cr. tomentosa* and allied plants now placed under the sect. *Sphaeritis*. The difference in the petals is too great to allow of their being placed side by side. The *Turrita* group also leads up to sect. *Globulea* (compare, *e.g.*, *Cr. albanensis* Schonl.).

145. **Cr. hemisphaerica** Thunb. in Nova Acta Nat. Cur., vi (1778), 331, Prodr., 57, Fl. Cap., ed. Schultes, 392; Willd., Sp. Pl., i, 1557; DC., Prodr., iii, 387; Harv. in Fl. Cap., ii, 367; Marloth, Trans. S.A. Phil. Soc., xviii, 48, t. 5, fig. 5, and Das Kapland, 227, fig. 3.—*Purgosea hemisphaerica* G. Don.

The type of this species is represented in Herb. Thunberg, Upsala, and Herb. Linnaeus, London (No. 35). In Herb. Thunberg there are two sheets: fol. *α* is very much like my var. *typica*; the two specimens on fol. *β* seem to belong to the same species but are more robust, each bears two inflorescences and the flowers in the partial inflorescences are not densely crowded, the pedicels being somewhat longer than in the type.

(*a*) *typica* Schonl. Reduced leaves on peduncle very small and acute, or absent, bracts of cymules very small, acute.

Matjesfontein, Nov., Dr. Purcell and Marloth, 3436.

(*b*) *foliosa* Schonl. Reduced leaves and bracts of the cymules conspicuous, broadly oval or subrotund, gradually diminishing in size upwards.

Between Hondewater and Warmbad in Klein Karroo, Ladismith division, Muir, 3671.

(*c*) *recurva* Schonl. (*Cr. rufopunctata* Schonl. in Rec. Albany Mus., ii (1913), 455); *Cr. turrita β latifolia* Harv. in Fl. Cap., ii, 348; *Cr. pyramidalis* E. et Z. MS.; *Cr. tetragona* E. et Z. MS. Resembling (*b*). Leaves on scape and bracts more or less recurved. Leaves rufopunctate (as in Thunberg's type).

Redhouse, Paterson, 1895; Amsterdamsvlakte, not far from the mouth of the Zwartkops River, Nov., Jan., Z. 2546; on the fields near the Zwartkops River, E. 1042; Towerwater Kloof, Willowmore division, Oct., Crampton, 81.

As Marloth has pointed out, this species takes a few years to develop flowers and then dies or propagates itself vegetatively by a few basal offsets.

146. **Cr. barbata** Thunb. in Nova Acta Nat. Cur., vi (1778), 329, 337,

Prodr., 57, Fl. Cap., ed. Schultes, 292; Linn., Syst. Veg., xiv, 306; Linn. f., Suppl., 188; DC., Prodr., iii, 388; Harv. in Fl. Cap., ii, 349; *Cr. turrita* Haw., Suppl., 17; *Cr. concinella* Haw. in Phil. Mag. (1823), 361; *Turgosea turrita* Haw., Rev., 17; Bot. Reg., t. 1344; *Purgosea barbata* G. Don, Hort. Brit. an Gen. Syst., iii; Marloth, Flora of South Africa, ii, 18, fig. 7, B, and Das Kapland, 226, fig. 88, 2. Type in Herb. Thunberg, Upsala (two specimens c. 18 cm. high); also in Herb. Linnaeus, London, No. 32.

Rocky places of the Hantam Mts. and Geelbeck River (ex Harvey); Nieuweveld Mts., near Beaufort West, July, c. 4000 ft., Marloth, 2137, 2148 (petals white with a rosy tinge); Laingsburg, Marloth; 13 miles from Touws River, Worcester division; Riversdale portions of Klein Karroo, 2000 ft., Sept., Muir, 3708 (petals whitish at base, purple in upper portion); hills at Adams Kraal, Ladismith division, 1200 ft., July, Muir, 3637 (petals white).

Harvey calls this a remarkable species. Except for the fact that its petals are not ending in channelled points it is very close to *Cr. interrupta* (sect. *Sphaeritis*). The short stamens attached at the end of the corolla tube and the short carpels with subsessile, subdorsal stigmata are noteworthy.

The following notes may supplement the description in the Fl. Cap.:—

Flowering stem quadrangular at base. Axis and branches of the inflorescence, bracts and sepals minutely papillose.

Measurements taken from Muir, 3708 (in which one flower was hexamerous):

Calyx-tube 1 mm., lobes 2–2½ mm. long.

Corolla tube 1½ mm., lobes 4–5 mm. long.

Filaments (filamentous) 1 mm., anthers 1 mm. long.

Carpels 2¼–2½ mm. long.

Squamae minute, yellow, broadly obcuneate rounded and emarginate at apex.

147. **Cr. corymbulosa** Link et Otto in Enum. Hort. Berol., i, 301, Ic. Pl. Sel., i, 39, t. 16; Harv. in Fl. Cap., ii, 348; Schonl. in Rec. Albany Mus., i, 115.

Cr. impressa Haw. in Phil. Mag., Sept. 24 [an D. Dietr. in Syn. Pl., ii, 1031 ?] (Haworth's drawing at Kew shows that his species belongs here); *Cr. pertusa* Haw. in Rev. Pl. Succ.

Cr. caffrariae Hort. Angl. (ex Link et Otto).

Pyrgosea aloides E. et Z., Enum., No. 1908.

Pyrgosea thyrsiflora E. et Z., Enum., No. 1907.

Purgosea corymbosula Loud., Nom., ed. 2, ii, 421; Sweet, Hort. Brit., ed. 2, 223 (fide Ind. Kew.).

Turgosea pertusa Haw. in Rev. Pl. Succ. (1821), 14 (ex Salm Dyck in Hortus dyckensis); (? *Purgosea pertusula* Haw. in Phil. Mag., iii (1828), 184).

Ecklon and Zeyher's No. 1908 can hardly be *Cr. aloides*, a species described by Solander in Ait. Hort. Kew., and adopted by Haworth. E. and Z.'s specimens were found at low altitudes near the Zwartkops River and Sundays River, Uitenhage division. Harvey based his description in the Fl. Cap., ii, 349, on these specimens. He has also stated that *Cr. acuminata* E. Mey. in Herb. Drege appears to be the same species.

The species occurs at Riversdale (Rust, 331, 333) and is common in the S.E. coast districts of Cape Province from the Humansdorp division (Haarlem, 2900 ft., Mar., Fourcade, 2102; Uitvlugt, 1200 ft., June, Fourcade, 2641) to Komgha and extends inland to Graaff Reinet, Queenstown, and Cala. It varies considerably in its vegetative organs. Sometimes it resembles forms of *Cr. turrita* Thunb., but can always be easily distinguished by its recurved petals. Already Harvey has pointed out that the stem and edges of the leaves are usually smooth, but sometimes the leaves are either papillate or ciliate on the edges and the stem more or less densely clothed with deflexed cartilaginous hairs. In the Records of the Albany Museum, i, 115, the writer has distinguished four varieties and mentioned some of their localities :

Var. *typica*, var. *major*, var. *lanceolata*, and var. *cordata*. As in *Cr. decidua*, the leaves in the last two varieties drop off at the flowering period and serves the purpose of copious vegetative reproduction.

(*Cr. thyrsiflora* Thunb. in Nova Acta Nat. Cur., vi, 139, Prodr., 55, Fl. Cap., ed. Schultes, 283; Linn., Syst. Veg., xiv, 307; L. f., Suppl., 190; Willd., Sp. Pl., i, 1559; DC., Prodr., iii, 387; *Cr. thyrsiflora* (L. f.) Harv. in Fl. Cap., ii, 367; *Purgosea thyrsiflora* Sweet, Hort. Brit., 2, 223.

Between Sundays River and Fish River (teste Thunberg). Leaves perfoliate ovate, obtuse. According to Linnaeus the inflorescence is a composite spicate corymb, according to Thunberg it is thyrsoid.

Cr. capitella Thunb. in Nova Acta, vi (1778), 339, Prodr., 55, Fl. Cap., ed. Schultes, 286; Linn., Syst. Veg., xiv, 307; Linn. f., Suppl., 190; Willdenow, Sp. Pl., i, 1558; Haworth, Syn. Pl. Succ., 58; DC., Prodr., iii, 387; Britten et Baker f. in Journ. of Bot., xxxv, 479. *Cr. capitellata* in DC., Prodr., iii, 387; Harv. in Fl. Cap., ii, 367.

In the Karroo between Cannaland and Oliphants River (teste Thunberg). Leaves oblong lanceolate, acute. Flowers verticillate. There are specimens at the British Museum.

Both these species probably are forms of *Cr. corymbulosa*, and if the evidence was clear one of these names would have priority.

Under *Cr. thyrsiflora* there are two specimens preserved in Herb. Thunberg at Upsala, but unfortunately only the flowering portions of two shoots. The inflorescences are looser than is usual in *corymbulosa* and they are distinctly peduncled, again a character not usual in *corymbulosa*.

The leaves are described by Thunberg as "perfoliate, ovate," which does not fit in either.

Under *Cr. capitella* there are two sheets in Herb. Thunberg, Upsala. Fol. α bears two specimens, one of which belongs to sect. *Globulea*, but is too defective to be determined accurately; the other may be *corymbulosa*, but in any case is close to it.

Fol. β bears a small specimen of *Cr. corymbulosa*, only about 10 cm. high with smooth-edged leaves (although Thunberg describes them as cartilaginous-ciliate).

Cr. capitella Soland. in Ait. Hort. Kew., i, 394, as preserved in Herb. Brit. Mus., appears to be =*corymbulosa*, and may be the species which Thunberg meant by his *capitella*).

148. **Cr. brevistyla** Bak. f. in Bull. de l'herb. Boiss. (2ième sér.) (1903), 813, t. 1903.

Umzyugati, 400 m., Wood, 942; near Mooi River, 1000 ft., Wood, 5346. Except that the flowers are larger than in the preceding species, there is practically no difference between them. In Wood, 942, the oblong petals are 4 mm. long (as against c. 2·5 mm. in *Cr. corymbulosa*), the sepals 2 mm. long. Baker states that the petals are lanceolate, 3·5 mm. long.

149. **Cr. Engleri** Schonl. in Rec. Albany Mus., ii (1907), 146.

Shady places in crevices of rocks, western slopes of the Bokkeveld, 600 m., Sept., Diels, 574. Type in Herb. Albany Mus.

A specimen in Herb. Marloth collected by Dr. Marloth (No. 7358) amongst shrubs at Van Rhyns Pass, alt. 300 m., in Oct. 1917, has exactly the same kind of subrosulate (though slightly larger) leaves as Diels' originals of *Cr. Engleri*. At first sight the latter seems, however, quite different as it has a thyrsoid subspicate inflorescence, whereas in Marloth, 7358, the lateral branches of the inflorescence are elongated. In Diels' plant no carpels could be found, although the anthers showed already fully developed pollen. Marloth's specimen has bisexual flowers. Yet I do not feel inclined to separate the two, as they agree in many respects, even in the floral structure. The following notes were based on Marloth, 7358:—

Perennial herb about 12 cm. high with subrosulate, ovate, subacute leaves, which are densely ciliate on the margin, glabrous on the surface, the largest about 3½ cm. long. Inflorescence terminal, pedunculate, peduncle glabrous, about 3 cm. long, with one pair of empty bracts which resemble the leaves but are very much smaller. Flowering region about 9 cm. long, with a number of lateral thyrsi, the lowest of which are about 5½ cm. long, diminishing in size upwards. Cymules on the thyrsi on short stalks, few-flowered, flowers subsessile. Calyx-lobes almost free, 2¼ mm. long, narrowly ovate. Petals almost free, yellow, elongated oblong, 4 mm. long. Stamens

2 mm. long. Carpels 1 mm. long, with a short recurved style and terminal stigma. Squamae minute, obovate, shortly stipitate.

150. **Cr. maculata** Schonl. n. sp,

Herbacea perennis e basi ramosa. Rami glabri vel sparse pilosi, teretes, c. 3 mm. diam., internodiis primum brevibus, foliis subrosularibus, deinde elongatis. Folia connata, tumida, ambitu oblonga, basi cuneata apice obtusa vel acuta supra subplana infra convexiuscula (interdum carinata), faciebus superioribus pallide viridibus maculis intense viridibus numerosis ornatis, inferioribus pallide viridibus vel rubriusculis, margine retrorsum ciliatis, c. 2·5 cm. longa, 1·2 cm. lata. Inflorescentia thyrsoidea. Pedunculus scabridus bracteatus, bracteis inferioribus vacuis foliis similibus superioribus floriferis sensim minoribus et eciliatis. Cymulae laxae pauciflorae, floribus breviter pedicellatis, pedicellis c. 5 mm. longis gracilibus apicem versus incrassatis. Sepala viridia glabra, basi connata tubo c. 5 mm. longo lobis lanceolatis c. 2·5 mm. longis. Petala alba oblonga emucronata (?), c. 4 mm. longa. Stamina et carpidia quam petala breviora. Ovaria oblique oblonga, stilis brevibus recurvis. Squamae membranaceae subrectangulares apice emarginatae.

Received in April 1925 from Miss M. Wilman, who found it cultivated in Mr. Tapcott's rock-garden, Kimberley. Type in Herb. Albany Mus.

151. **Cr. Broomii** Schonl. in Rec. Albany Mus., ii (1907).

Pampoon Poort, near Victoria West, Oct., Dr. Broom; Victoria West, Sept., Jansen; also at Three Sisters. Type in Herb. Albany Mus.

This, when dry, has quite the appearance of broad-leaved forms of *Cr. turrita*. Apart from other distinguishing characters, it has distinct subulate styles (about ½ the length of the somewhat slender ovaries), and the stigmata are elongated, placed on the dorsal side of the apex of the styles.

Exilis group.

152. **Cr. exilis** Harv. in Fl. Cap., ii, 347.

Namaqualand (teste Harvey). Only known to me from description. A sketch of the original (in Herb. Dublin ?) is in the British Museum Herb.

153. **Cr. garibina** Marl. et Schonl. n. sp.

Perennis humilis c. 6 cm. alta, caule subcarnoso inferne efoliato c. 8 mm. diam., superne foliorum c. 5 paribus dense instructo. Folia connata crassa grisea papillis parvis densissime tecta ambitu ovata basi contracta subacuta c. 1·6 cm. longa, c. 1 cm. lata. Inflorescentiae terminales et ex axillis foliorum superiorum laterales, cymoso-corymbosae pauciflorae pedunculo c. 1·5 cm. longo, 2 bracteis instructo, griseo minutissime dense papilloso, pedicellis brevibus. Calyx extus griseus breviter papilloso-tomentosus tubo c. ½ mm. alto. lobis ovatis 1¼–1½ mm. longis. Corolla luteo-alba tubo vix

$\frac{1}{2}$ mm., alto lobis oblongo-lineatis erecto-patentibus infra apicem dorso mucronulatis $2\frac{1}{2}$–$2\frac{3}{4}$ mm. longis. Carpidia gracilia ovariis oblique oblongis c. $1\frac{1}{4}$ mm. longis, stilis filiformibus c. 1 mm. longis, stigmatis parvis terminalibus. Squamae c. $\frac{1}{4}$ mm. longae latiores quam longae apice rotundatae et leviter emarginatae.

In the desert at the mouth of the Orange River, 200 ft., Sept., Marloth, 12507. Type in Herb. Albany Mus.

This species has somewhat the habit of *Cr. arta* Schonl. (*Cr. deltoidea* auct. non Thunb.), but while in this and closely allied species the stigma is subsessile, in *Cr. garibina* there is a distinctly filiform style; further, the peduncle here is short and not so slender as in *Cr. deltoidea* and its near allies, the flowers are somewhat larger.

154. **Cr. klinghardtensis** Schonl. n. sp.

Perennis carnosa c. 5·5 cm. alta caule dense foliato c. 2·5 cm. longo cum foliis columnam quadrangularem formans. Folia subglobosa, ambitu ovata subacuta, patentia grisea dense sed minutissime pubescentia connato-perfoliata extus valde convexa intus convexa inferne canaliculata c. 1 cm. longa, c. 1 cm. lata et c. 6 mm. crassa. Internodia brevissima. Pedunculus c. 2 cm. longus terminalis teres pubescens apice trifurcatus bractearum vacuorum c. 1·5 mm. longorum 3 paribus instructus. Cymulae capitatae floribus subsessilibus. Sepala c. 2 mm. longa lobis c. 1·1 mm. longis oblongis obtusis dorso pubescentibus convexis. Petala alba sublibera erecta apice leviter recurva sublinearia acuta infra apicem dorso minutissime mucronulata, c. 3·5 mm. longa. Stamina c. 3 mm. longa, filamentis albis applanato-subulatis, antheris brunneis. Carpidia albo-viridia c. 3 mm. longa, ovariis c. 2 mm. longis oblique oblongis margine centrali minutissime ciliato, apicem versus in stilum brevem attenuatis, stigmatis subdorsalibus. Squamae parvae obcuneatae submembranaceae late obcuneatae apice emarginatae.

Klinghardt Mts., S.W. Protectorate, Dinter, 9 (flowered in Grahamstown, Sept. '25). Type in Herb. Albany Mus.

155. **Cr. Luederitzi** Schonl. n. sp.

Herba succulenta caespitoso-ramosa c. 3·5 cm. alta. Folia 6–10 conferta, sessilia vix connata c. 1 cm. longa, patentia apice interdum leviter recurva vel suberecta, deltoideo-ovata apice subacuta supra subplana vel convexiuscula, dorso convexa carinata, faciebus cinereis, in sicco irregulariter squamigeris, margine dense papilloso-ciliata. Pedunculus glaber terminalis gracilis, c. 1·2 cm. longus prope medium bracteis 2 lanceolatis instructus. Inflorescentia terminalis subcapitata pauciflora. Sepala glabra breviter connata deltoidea ovata subacuta, lobis 1–$1\frac{1}{4}$ mm. longis glabris. Petala erecto-patentia apice leviter recurva breviter connata, anguste rhomboidea basi cuneata apice acuta infra apicem dorso mucronulata, $3\frac{1}{4}$–

3½ mm. longa. Stamina c. 2½ mm. longa. Carpidia 2½ mm. longa, ovariis oblique ovatis, stilis vix 1 mm. longis gracilibus, stigmatis parvis capitatis. Squamae parvae obcuneatae apice rotundatae et leviter emarginatae.

Luderitz, Stöber in Herb. Marloth, 11918.

This species has a great resemblance to *Cr. humilis* N. E. Br. in Kew Bull., 1911, 357, but the author does not mention in this species marginal papillae on the leaves; further, its petals are only 2–2·3 mm. long; lastly, according to the author it has no styles, the stigmata being sessile. All this seems to show that the resemblance is only superficial. Its affinity seems to be more with *Cr. exilis* Harv.

Arta group (*Imbricatae* Harv. in Fl. Cap., ii, 334, p. pte.).

156. **Cr. arta** Schonl. nom. nov. (*Cr. deltoidea* Harv. in Fl. Cap., ii, 350, et auct. al., non Thunb.).

Lieslap, Namaqualand, Z.

Pearson's 6174, which I referred to this species in Ann. S.A. Mus., ix, 49, is, according to Mr. N. E. Brown, the following one (which I had distributed as *Cr. Alstonii* Schonl. MS. before Marloth published a species under the same name). However, there are specimens in Herb. Albany Museum, collected by Mr. G. Alston in Namaqualand, which must be referred to *Cr. arta*, and these were described as *Cr. deltoidea* Thunb. by Bak. f. and the author in Journ. of Bot., 1902, 284.

157. **Cr. Bakeri** Schonl. n. sp.

Perennis nana crassa e basi ramosissima, rami foliis emarcidis persistentibus tectis, ramuli 4–6 foliis munitis, internodiis ½–2 mm. longis; folia glauco-viridia vel rubescentia pubescentia vel subglabra, connato-subperfoliata subpatentia, 5–10 mm. longa, ovata obtusa vel obovata, dorso convexa interdum versus apicem carinata, intus apice subplana, basi leviter excavata. Inflorescentia terminalis, laxe cymoso-corymbosa pauciflora, pedunculata, pedunculo gracili pubescenti vel sub-glabro, c. 4 cm. alto, 2–4 bracteis parvis sterilibus instructo, floribus subcampanulatis pedicellatis, pedicellis 1·5–2 mm. longis. Sepala tenuia c. 1·5 mm. longa, lobis c. 1 mm. longis ovatis obtusis dorso pubescentibus vel subglabris, margine ciliatis, viridia vel basi pallide viridia apice rosea. Petala paullo recurva, basi connata, ovata, apice dorso mucronulata, alba, 2 mm. longa. Stamina 1 mm. longa, filamentis linearibus apice attenuatis, antheris ovatis. Carpidia staminis subaequilongis, stilis subnullis, squamis pallide luteis membranaceis late cuneatis apice emarginatis c. ½ mm. longis.

Described from live specimens received from Mr. Garwood Alston, who collected them at Hondeklip Bay and Garies, Namaqualand (flowered in Grahamstown in Nov. and Dec.). Type in Herb. Albany Mus.

This species is closely allied to *Cr. arta* and agrees with it fairly closely in the inflorescence and structure of the flower, but the somewhat spreading leaves are never deltoid. The branching is richer in this species and the branches are shorter.

158. **Cr. humilis** N. E. Br. in Kew Bull., 1911, 357.

South-western part of Cape Colony, Pearson, 5484. Type in Herb. Kew.

According to the author it is closely allied to *Cr. deltoidea* Harv. (non Thunb.), from which it differs by the leaves being deltoid ovate, patent, not imbricate, green or slightly ashy green, scarcely glaucous, and by erect petals.

159. **Cr. globosa** N. E. Br. in Kew Bull., 1911, 356.

South-western part of Cape Colony, Pearson, 5474. Type in Herb. Kew.

According to the author it is also allied to *Cr. deltoidea* Harv. (non Thunb.=*Cr. arta* Schonl.), but the subglobose leaves, resembling small marbles, flattened on one side, the upper arranged in about three pairs in each growth, give this plant a very distinct appearance.

160. **Cr. cornuta** Schonl. et Bak. f. in Journ. of Bot., xl (1902), 285.

Namaqualand, E. G. Alston (flowered in Grahamstown, May–Sept.); Klinghardtgebirge, S.W. Africa, Dinter, 11 (p. pte.). Type in Herb. Albany Mus.

161. **Cr. columella** Marl. et Schonl. n. sp.

Perennis parce ramosa, caule sublignoso efoliato vel foliis emarcidis totum tecto. Rami foliis dense imbricatis totum tecti cum foliis tetragono-columnares 3·6–5 cm. longi c. 12 mm. lati, foliis inferne emarcidis, superioribus crassis carnosis connato-perfoliatis griseo-pubescentibus subdeltoideis apice obtusis. Pedunculus gracillimus terminalis c. 3·5 cm. longus pubescens, bracteis vacuis 4 parvis acutis instructus, apice parce et laxe cymoso-ramosus. Flores breviter pedicellati. Calyx extus pubescens, sepalis connatis tubo $\frac{3}{4}$ mm. longo, lobis lanceolatis acutis vel subobtusis 1·25 mm. longis. Corolla luteo-alba extus minutissime pubescens, petalis basi connatis suberectis subnavicularibus dorso infra apicem minute mucronulatis 1·5–1·75 mm. longis. Stamina quam petala breviora. Carpidia 1 mm. longa, ovariis oblique ventricosis dorso et ad lineam ventralem parce ciliatis, stilis subnullis stigmatis parvis subdorsalibus. Squamae parvae late obcuneatae apice rotundatae et emarginatae.

Amongst rocks, Richterveld, Namaqualand, 1000 ft., Aug. '25, Marloth, 12271. Type in Herb. Albany Mus.

This species is allied to *Cr. arta*. It is easily distinguished from this species by its pubescent leaves and relatively shorter suberect petals. The amount of hairiness on the leaves varies.

162. **Cr. deceptrix** Schonl. (*Cr. deceptor* Schonl. et Bak. f. in Journ. of Bot., xi (1902), 285).

Namaqualand, E. G. Alston; Richtersveld, western slopes of ridge between Dannabis and Bethany Drift, Dec., Pearson, 6056; in sand under quartzose rocks on hills north of Modderfontein, Jan., Pearson, 6160; Little Namaqualand, slopes at Eenriet, Jan., Pearson, 4079, also 6210. Type in Herb. Albany Mus.

163. **Cr. Alstoni** Marl. in Trans. Roy. Soc. South Afr., i (1910), 404, t. 27, fig. 7.

Near Anenous, Little Namaqualand, G. Alston (flowered in Capetown in Apr., Marloth, 4679); Chubiessis outspan, Namaqualand, Jan., Pearson, 6174, in Herb. Kew.

164. **Cr. hottentotta** Marl. et Schonl. n. sp.

Perennis caule brevi basi sublignoso tereti basi efoliato parce ramoso ramis teretibus dense papillosis 2–3 cm. longis, foliorum 3–4 paribus instructis, internodiis quam folia multo minoribus. Folia grisea crassissima ambitu late ovata vel obovata obtusa intus subplana, papillis subglobsis densissime tecta subtessellata connata 1·2–1·6 cm. longa, 1–1·5 cm. lata. Pedunculus gracilis terminalis c. 4 cm. longus bracteis 2 vacuis instructus apice capitulum 3-furcatum gerens. Calyx extus pubescens, tubo vix $\frac{3}{4}$ mm. alto, lobis ovatis ad margines ciliatis. Corolla extus $\pm$ puberula tubo brevi $\pm$ $\frac{1}{2}$ mm. alto, lobis erectis navicularibus, infra apicem dorso mucronulatis, $2\frac{1}{2}$ mm. longis. Stamina c. 2 mm. longa, filamentis subulatis c. 1 mm. longis, antheris ovatis. Carpidia $1\frac{1}{2}$ mm. longa ovariis dorso subumbonatis, stilis brevissimis, stigmatis terminalibus. Squamae brevissimae, c. $\frac{1}{2}$ mm. latae, apice leviter rotundatae et emarginatae.

Richtersveld, Namaqualand, on laminated rocks, 1000 ft., Aug., Marloth, 12506. Type in Herb. Albany Mus. and Herb. Marloth.

This new species approaches *Cr. deceptrix* in its subtessellate leaves, but otherwise it comes closer to *Cr. cornuta*. On the other hand it comes also very close to *Cr. namaquensis* var. *brevifolia* Schonl.

165. **Cr. mesembrianthoides** Schonl. et Bak. f. in Journ. of Bot., xl (1902), 284.

Hondeklip Bay, E. G. Alston; on sands, Stinkfontein plateau, Jan., Pearson, 6215. Type in Herb. Albany Mus.

For a full description see Schonland in Ann. S.A. Mus., ix, 49.

(*Cr. mesembrianthemoides* Dinter et Berger in Engl. Bot. Jahrb., l (Suppl., 1914), is not known to me. It cannot be recognised from the description as the flowers are not sufficiently described. The authors state that it cannot be placed into any of Harvey's sections in the Fl. Cap. I append the original description and notes.

Rosulae dense caespitosae, subglobosae. Folia c. 6–8 dense congesta, carnosa semigloboso-cymbiformia, supra plana subtus valde convexa et carinata, obtusa vel breviter acuminata angulis acutis, exteriora c. 10 mm.

longa et lata, interiora minora, glabra basi ad margines minute fimbriato-pubescentia. Pedunculi 20 mm. longi, ebracteati, minute puberuli, apice 2–3 furcati, pauciflori, bracteis parvis lanceolatis fimbriatis. Flores c. 6–7 sessiles 3–4 mm. longi; calycis lobi lanceolati, puberuli, petala alba paullum longiora, acuta, apice recurvula. Lüderitzbucht: Auf Gneisfelsen, mit kleinen, weiben Blüten (Dinter, No. 1014).

Diese eigentümliche *Crassula* lässt sich in keiner der von Harvey in Fl. Cap., ii, 332 usw. gegebenen Sektionen unterbringen. Die kleinen, dichten Rasen ähneln etwas denen gedrängt gewachsener Mes. Lehmanni. Das mir vorliegende Stück ist c. 4 cm. breit und 3 cm. hoch. Ohne Blüte würde man die Pflanze für ein Mesembrianthemum halten können.)

(*Cr. mesembrianthemoides* D. Dietr., Syn. Pl., ii, 1031, is not known to me either. It is probably *Cr. trachysantha*.)

166. **Cr. elegans** Schonl. et Bak. f. in Journ. of Bot., xl (1902), 286.

Garies, Namaqualand, E. G. Alston. Flowered in Grahamstown, Oct. 1897. Type in Herb. Albany Mus.

167. **Cr. Dinteri** Schonl. n. sp.

Perennis carnosa 4–8 cm. alta parce ramosa. Rami foliiferi ad 3 cm. longi, foliis 6–8 dense imbricatis subpatentibus instructi. Folia basi connata sessilia crassa ambitu ovata obtusa vel subacuta supra subplana basi excavata, glaucoviridia, interdum infra medium rufo-punctata, minutissime pubescentia, ad 1 cm. longa et ad 8 mm. crassa. Pedunculus terminalis gracilis interdum flexuosus, minute pubescens, ad 2·5 cm. longus, apice vel infra medium cymoso-ramosus, cymis laxis vel apice congestis, floribus subsessilibus bracteis parvis lanceolatis vel ovatis acutis minute pubescentibus. Calycis lobi late ovati carnosi obtusi extus pubescentes, margine ciliati 1–1¼ mm. longi, tubo brevi. Corolla albida, lobis suberectis apice leviter recurvis oblongo-linearibus dorso infra apicem minutissime mucronatis c. 3 mm. longis, tubo c. 1 mm. longo. Stamina ad faucem corollae affixa c. 2 mm. longa. Carpidia 1–1¼ mm. longa, ovariis oblique ovatis 1 mm. longis viridibus stigmatis terminalibus subsessilibus crassis rubriusculis. Squamae membranaceae luteae late obcuneatae apice rotundatae et emarginatae ⅓–½ mm. longae.

Klinghardtgebirge, S.W. Protectorate, Dinter, 2 and 11 (p. pte.). Flowered in Grahamstown, Jan. '25. Type in Herb. Albany Mus.

168. **Cr. grisea** Schonl. in Ann. S. Afr. Mus., ix (1912), 50.

Little Namaqualand; Richtersveld, rocky places (facing west) north of pass between Dannabis and Bethany Drift, Dec., Pearson, 6054. Type in Herb. Albany Mus.

ARGYROPHYLLA group.

169. **Cr. argyrophylla** Diels; Schonl. et Bak. f. in Journ. of Bot., xl (1902), 290; Diels in Engl. Bot. Jahrb., xxxix (1907), 465.

Common on hills near Pretoria and elsewhere in the Transvaal, extending to Swaziland and Rhodesia (Pole Evans, 3230, was marked Aliwal North; Marloth, 11043, is supposed to have been collected by Dr. Broom at Bruintjeshoogde, Somerset East district); Braamfontein, 6000 ft., Jan.-Feb., Galpin, 6211; Pretoria, Pole Evans, Burtt-Davy, Collins, 175; Middelburg district, Marloth, 11773; Pyramid estate, Potgietersrust, amongst rocks on upper slopes of granite mountains, 6500 ft., Mar., Galpin, 8809; Lydenburg, Nov., Wilms, 527, and Pole Evans, 1311. Type in Herb. Albany Mus.

Var. *ramosa* Schonl. Much branched, leaves smaller (about 1·3 cm. long), inflorescences small, subcapitate.

Waterval Boven, Aug., Rogers, 2745, in Herb. Albany Mus.

Var. *swaziensis* Schonl. Leaves, except on margin, glabrous.

Cr. swaziensis Schonl. in Journ. Linn. Soc. (Bot.), xxxi (1897), 548.

Havelock Concession, Swaziland, 3500 ft., July, Galpin, 992, in Herb. Albany Mus.

170. **Cr. pachystemon** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 367. *Cr. cathcartensis* O. Ktze. MS. in Herb. Berol. Type in Herb. Albany Mus.

Rocky hillsides near Graaff Reinet (Ryn Pass), 2600 ft., May, Bolus, 437 (also collected by Rattray near Graaff Reinet); Windvogelberg, near Cathcart, July, Sim; *ibid.*, Feb., O. Kuntze; under rocks on hillsides, Mt. Hope Farm, Upper Zwart Kei, 5400 ft., Mar., Galpin, 2645.

Mr. J. G. Baker thinks that this is allied to *Cr. mollis* Thunb. in Nova Acta Acad. Leop. Car., vi, 340 (1778); but this belongs to sect. *Globulea*.

171. **Cr. Ernesti** Schonl. et Bak. f. in Journ. of Bot., xl (1902), 283.

Amongst rocks, Bowker's Pass, Queenstown, 4800 ft., Jan., Galpin, 2563; Cala, near Bushman caves, c. 4000 ft., Feb., Pegler, 1536. Probably this species must be sunk in *Cr. pachystemon*.

172. **Cr. decidua** Schonl. n. sp.

Herba perennis carnosa e basi ramosa 10–12 cm. alta. Rami suberecti foliati internodiis inferioribus c. 7 mm., superioribus 1–1$\frac{1}{4}$ cm. longis, caulibus teretibus minute sed dense pubescentibus c. 2 mm. diam. Folia connata decidua carnosa subcultrata obovata vel oblique obovata basi attenuata supra subplana dorso convexa utrinque grisea minutissime papillosa inferiora 2 cm. longa, superiora gradatim minora. Inflorescentia terminalis breviter thyrsoidea, bracteis parvis, cymulis breviter pedunculatis vel sessilibus capitatis paucifloris. Calyx gamosepalus tubo 1–1$\frac{1}{4}$ mm. longo, lobis ovato-oblongis 1$\frac{1}{2}$–1$\frac{3}{4}$ mm. longis dorso papillosis margine ciliatis.

Corolla alba gamopetala tubo $\frac{1}{2}$–$\frac{3}{4}$ mm. longo lobis erectis ad margines leviter revolutis oblongis infra apicem dorso minutissime mucronulatis 2 mm. longis. Stamina quam corolla vix breviora filamentis crassis tubo corollae adnata. Carpidia $1\frac{3}{4}$–$2\frac{1}{4}$ mm. longa ovariis oblique oblongis stilis brevibus stigmatis subdorsalibus. Squamae luteae carnosae subrectangulares apice emarginatae c. $\frac{1}{2}$ mm. longae.

Cookhouse, Bolus, 9309; about 30 miles S.W. of Somerset East on the way to the farm De Toekomst, locally common amongst *Euphorbia coerulescens* with *Cr. Rogersii*, R. A. Dyer, 691, Nov. '26, flowered in Grahamstown, Feb.–Mar. '27; Fish River Valley, 5 miles south of Committees, Dyer, 869.

About the time of flowering, this plant, like some forms of *Cr. corymbulosa*, sheds its leaves from above downwards. The leaves become detached just above the base, leaving a comparatively thick scar. Each leaf develops, even before being detached, a small adventitious bud by means of which extensive vegetative reproduction is ensured.

173. **Cr. lanuginosa** Harv. in Fl. Cap., ii, 347; *Cr. strigosa* Drege.

Gaatje, near the Stormberg, 5000 ft., and Nieuwe Hantam, 4500–5000 ft. (ex Harvey); Middelburg, Cape, Jan., Bennie, 690; in krantzes, Bangor Farm, Middelburg district, Cape, occasional, c. 4000 ft., Jan.–Feb., Bolus, 14125; Cradock, June, Sim; Majuba Nek, Sterkstroom division, Hepburn, 202.

The plant has a similar habit as *Cr. corallina* Thunb.

(*Cr. pubescens* Thunb. in Nova Acta, vi (1778), 330, 340, Fl. Cap., ed. Schultes, 385; Linn., Syst. Veg., xiv, 307; L. f., Suppl., 194; Linn., Sp. Pl. (ed. 4), 1548; DC., Prodr., iii, 386 under Deltoideae), "Carro prope Cannaland" (ex Thunberg).

This species evidently belongs to this group, but it cannot be decided from the description whether any of the above species must be referred to it. The specimens in Herb. Thunberg at Upsala under the name "*Cr. pubescens*" cannot belong to it. They have quite glabrous leaves. I would refer the specimens to *Cr. radicans* D. Dietr.)

Sect. V. SPHAERITIS (E. et Z.) Schonl. emend.

(Sect. *Sphaeritis*, *Margarella*, and *Pachyacris* Harv. in Fl. Cap. ii, 336; *Sphaeritis* E. et Z. as a genus. Schonl. in Engl. Bot. Jahrb., xlv, 250. Specimens mentioned in this paper are not as a rule enumerated again.)

Ramosa group.

174. **Cr. ramosa** Thunb. in Nova Acta Nat. Cur. (1778), 330, 341, Prodr., 55, Fl. Cap., ed. Schultes, 284; *Cr. capitata* Lam., Enc., ii (1786),

171; *Cr. Sphaeritis* Harv. in Fl. Cap., ii, 359; Schonl. in Engl. Bot. Jahrb., xlv, 252, and Ann. S. Afr. Mus., ix, 52.

Cr. fruticulosa E. Mey. in Coll. Drege; *Sphaeritis typica* E. et Z., *Sph. muricata* E. et Z., *Sph. stenophylla* E. et Z. in Enum., Nos. 1910, 1911, 1912.

Thunberg's name has been adopted, as the specimen bearing his name at Upsala is undoubtedly $=$*Cr. Sphaeritis*. The same is the case with the specimens named *Cr. capitata* in Lamarck's Herb. at Paris.

Cr. subulata in the Linnean Herbarium, London (Nos. 21 and 22), is$=$ *Cr. subulata* Berg. in Descr. Plant. ex C. B. Sp. (1767), 83. This is the plant now known as *Rochea odoratissima* DC. The same species goes as *Cr. subulata* in Herb. Thunberg. Then there is *Cr. subulata* (Hook.) Harv. in Fl. Cap., ii, 352 (now called *Cr. transvaaliensis* O. Ktze.). On the other hand, in Herb. Willdenow at Berlin the plants named *Cr. subulata* L. are certainly $=$*Cr. Sphaeritis* Harv. Willd. in Linn., Sp. Pl., ed. 4 (1797), 1559, quotes Pet. Gaz., t. 69, fig. 8, and Herm. Lugd., 555, t. 552. I have long suspected that the latter might represent *Cr. Sphaeritis* Harv., but it seems that some of the earlier authors, and perhaps also Linnaeus, did not see always the distinction between this species and the species which he himself described as *Cr. cymosa* in Mant., 222. Thus the name *Cr. subulata* L. is better dropped.

This species varies considerably (see Fl. Cap., ii, 359, and my remarks under *Cr. fastigiata* Schonl.).

Common in the coast districts from Capetown to Port Elizabeth. Collections of typical specimens not previously quoted: Karbonkelberg, Cape Peninsula, Dec., Pillans, 3768; Dunes near Hawston, 20 ft., Nov., Schlechter, 9476; Worcester division, 1050 m., Stockoe, 1172*a*; De Doorns, Hex River, Jan., Bolus, 13102; Riversdale, Oct.–Dec., Feb., Bartlett, 3, 14, Muir, 95, Rust, 71, 475, 187, 608; banks of Knysna River, 50 ft., Sept., Galpin, 4018; south side of mountain between Uniondale and Avontuur, Dec., Schonland, 3344. The following notes taken from live specimens collected at Port Elizabeth (J. L. Drege, 374, and Trash, 26) will supplement the description in the Fl. Cap.:—

Calyx 2 mm. long, lobes $1\frac{3}{4}$ mm. long, lanceolate obtuse, quite glabrous. Petals milky white, 2·5 mm. long, lobes 2·25 mm. long, Stamens 1·25 mm. long. Anthers oblong, yellow, pollen yellow. Filaments white, subulate. Carpels 1·25 mm. long, white, styles very short, thick. Stigmata just behind the apex of the styles. Squamae yellow, membranous, a little more than half the length of ovaries, obcuneate, rounded and slightly emarginate at the apex.

175. **Cr. multiflora** Schonl. et Bak. f. in Journ. of Bot., xxxvi, 338; Schonland, *loc. cit.*, 252.

The type of this species was found at Montagu (Herb. Bolus and Herb. Albany Mus.). It was further found at Riversdale. Additional specimens:

Montagu, Arbuthnot, 1225, 1924; slopes of Langberg at Glen, 800–1000 ft., Dec., Muir, 3046.

The following notes taken from Muir's specimens will supplement the original description :—

Up to 2 ft. high, leaf-sheaths 5–6 mm. long. Leaves sublinear (slightly oblong and oblique), obtuse or subacute, flat, minutely bullato-ciliate on the margin, mostly 3·6 cm. long and about 5 mm. broad, uppermost much smaller and narrower. Sepals 3 mm. long, lobes lanceolate acute with only a few minute delicate cilia on the margin, convex on back, concave on the adaxial side, 2 mm. long. Petals white, recurved from the middle, contracted above the middle and slightly channelled, united at the base, 4 mm. long. Stamens at base united to the corolla tube. Filaments very slender, thickened at the apex, flattened. Carpels barely 2 mm. long with short, thick, slightly recurved styles. Stigmata subdorsal.

176. **Cr. fastigiata** Schonl. n. sp.

Suffruticosa 25–50 cm. alta, caule ramis ramulisque teretibus lignosis. Caulis c. 6 cm. longus subdichotome laxe ramosus efoliatus 5–6 mm. diam. glaber. Rami suberecti annulati efoliati sparse pilosi basi c. $3\frac{1}{2}$ mm. diam. apicem versus minores. Ramuli erectiusculi c. 5–10 cm. longi, 1·5 mm. diam. pilosi totum foliati. Folia viridia laxe imbricata connata ovalia acuta utrinque glabra ad margines papilloso-ciliata, ciliis patentibus. Inflorescentiae terminales dense cymoso-capitatae subsessiles 1–2 cm. diam. c. 5 mm. altae apice subplanae, bracteis quam folia minoribus lineari-lanceolatis. Sepala basi connata tubo c. $\frac{1}{2}$ mm. longo lobis subnavicularibus anguste oblongis subacutis vel obtusis viridibus ad margines papilloso-ciliatis 2–2·25 mm. longis. Petala primum alba deinde luteola basi connata tubo c. 1 mm. longo lobis erecto-patentibus basi oblongis navicularibus apicem versus linearibus obtusis parte superiore primum plano deinde subplicato, 2·25 mm. longis. Stamina tubo corollae affixae, filamentis filamentosis 1 mm. longis, antheris oblongis $\frac{1}{4}$–$\frac{1}{2}$ mm. longis, luteis. Carpidia $1\frac{3}{4}$–2 mm. longa, ad margines ventrales ciliolata, ovariis subventricosis stilis brevissimis stigmatis parvis subterminalibus. Squamae primum carnosae deinde membranaceae obcuneatae apice leviter rotundatae et emarginatae $\frac{3}{4}$ mm. longae.

On the fixed dunes near sea at Melkhoutfontein, 100 ft., Oct., Dr. J. Muir, 3380. Type in Herb. Albany Mus.

This species is closely allied to *Cr. ramosa* Thunb., but has quite different leaves, which are more closely crowded on the branchlets, and have larger cilia on the margin.

Specimens, collected by Mrs. A. T. Williamson (No. 137) in January on the banks of the Knysna lagoon near the roadside to the East Heads, must be placed under this species, although they differ in the following particulars :

The internodes are slightly longer, the leaves on some branches are narrower the flowers are slightly larger (sepals 3 mm., petals 4 mm. long). Some of the leaves are without marginal cilia, others have them only on one side. The latter peculiarity is also often found in the sepals. Other specimens collected in the Knysna-Zitzikama region cannot be directly referred to any described species (*e.g.* Schonland, 3391, Knysna Heads; Rogers, 28379, Plettenberg Bay; Fourcade, 1464, sand-dunes, Groot River; Fourcade, 571, seashore, Ratelsbosch). It is almost possible to form a connected series leading on the one hand from *Cr. ramosa* to *Cr. fastigiata*, and on the other from *Cr. ramosa* to *Cr. multiflora* Schonl. et Bak. f.

177. **Cr. Rustii** Schonl. in Engl. Bot. Jahrb., xliii (1909), 361.

Riversdale, Rust, 144. Type in Herb. Berlin.

178. **Cr. hispida** Schonl. et Bak. f. (non Haw.) in Journ. of Bot., xxxvi (1898), 368.

Rocky hills near Montagu Baths, 800 ft., Dec., Bolus, 6704. Type in Herb. Bolus and Albany Mus.

179. **Cr. leucantha** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 369.

Howhoek, 2000 ft., Feb., Schlechter, 7378. Type in Herb. Albany Mus.

180. **Cr. Rudolfi** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 363.

Western Region, Brakdamm, on hills, 1500 ft., Sept., Schlechter, 1897.

This undoubtedly belongs to the *Ramosa* group. The original description was made from immature flowers.

Clavifolia group.

181. **Cr. clavifolia** (E. Mey.) Harv. in Fl. Cap., ii, 360; Schonl., *loc. cit.*, 252.

Globulea clavifolia E. Mey. b in Herb. Drege (Herb. Kew).

Namaqualand to Port Elizabeth.

(*a*) *typica* Schonl. Leaves not crowded on the branches, flattish, without marginal cilia, glabrous or subglabrous on the surface.

Namaqualand, E. G. Alston; on hills at Garies, 1000 ft., Sept., Schlechter, 11100.

(*b*) *rosularis* Schonl. Leaves more fleshy than in (*a*) and (*c*), crowded at the base of the branches, without marginal papillae, glabrous or subglabrous on the surfaces.

Riversdale, ? 1357; Knysna, 100 ft., Feb., J. Phillips, 26; Knysna Heads, south side, Dec., Schonland, 3539 (one specimen with elongated internodes); Formosa, Plettenberg Bay, 200 ft., Jan., Fourcade, 1056; Oudtshoorn, July, Britten, 177; Humansdorp, Aug., Rogers; Walmer, near Port Elizabeth, Aug., Paterson, 691 (type of *Cr. micrantha* Schonl. in Engl. Bot. Jahrb., xlv, 255).

(*c*) *marginata* Schonl. in Rec. Albany Mus., i, 117.

Leaves not crowded, minutely papillose-ciliate on the margin, surface glabrous or subglabrous.

Montagu, 300 m., Oct., Marloth, 3239; De Doorns, c. 1700 ft., Jan., Bolus, 13100; Riversdale, Dec., Volschenck, Rust, 206; rocky places on the Zwartberg, 1500 ft., Dec., Schlechter, 9793; Seven Weeks Poort Mt., north side, frequent, 6700 ft., Andreae 1350, Stokoe 1778.

(*d*) *Muirii* Schonl. Leaves crowded at the base of the branches, more distinctly pubescent than in the other varieties (as are also the peduncle, bracts, and calyx-lobes), margin sometimes papillose-ciliate.

Hills near Riversdale, 800 ft., Oct., Muir, 3792; Riversdale, Muir, 3792*a* (according to the collector it differs from 3792 by (1) less hairiness, (2) delayed flowering date, (3) increase in height). The following are some notes taken from these two numbers when alive :—

Muir, 3792. A shrublet, laxly branched from near the base, 10–12 cm. high when in flower. Leaves, peduncles, bracts, and calyx distinctly pubescent. About four pairs of leaves crowded near the base of the branches. Calyx $2\frac{1}{2}$–$2\frac{3}{4}$ mm. long, tube short (about $\frac{1}{4}$ mm.), light green, lobes subligulate, obtuse, somewhat thickened towards the apex, pubescent on the back, ciliate on the margin. Corolla $3\frac{1}{2}$ mm. long (tube $\frac{1}{4}$–$\frac{1}{2}$ mm. long), white, lobes oblong, gradually tapering into a slightly channelled point with a dorsal globular rudimentary mucro at the back near the apex. Filaments $1\frac{1}{4}$ mm. long, anthers $\frac{3}{4}$ mm. long. Carpels $1\frac{1}{2}$–$1\frac{3}{4}$ mm. long, ovaries passing gradually into a short thick style. Ovaries with a few hairs on the inner angle. Stigmata dorsal at the apex. Squamae yellow, nearly $\frac{1}{2}$ the length of the ovaries, obcuneate, emarginate at the apex.

3792*a*. Small subshrub c. 17 cm. high when in flower. Less distinctly pubescent than 3792. Calyx-segments lanceolate, subacute, but otherwise there are only minute differences in the floral structure.

182. **Cr. sericea** Schonl. in Engl. Bot. Jahrb., xlv (1910), 254.

I'aus, on hills, c. 900 ft., Sept., Schlechter, 11436; Bokkeveld at Nieuwe Rust, Marloth, 5292; Swellendam, in camp below station, Smith, 2726*a*. For further records in Namaqualand and Bushmansland see Schonland in Ann. S.A. Mus., ix, 53, where also a few additional characters of the species will be found. Type in Herb. Albany Mus.

183. **Cr. anomala** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 370.

Mountains near French Hoek, 2000 ft., Nov., Schlechter, 9317. Type in Herb. Albany Mus.

Remarkable for its subapical globular dorsal mucro, which, however, is indicated in some forms of *Cr. clavifolia* as shown above.

184. **Cr. ciliata** L., Sp. Pl., 405, Hort. Cliff., 496; Mill., Dict., No. 4; Dillenius, Hort. Elth., t. 98, fig. 116; Thunb. in Prodr., 56, Fl. Cap.,

ed. Schultes, 288; Ait. Hort. Kew., i, 394; DC. in Pl. Gr., t. 7, Prodr., iii, 387; Harv. in Fl. Cap., ii, 360; Schonl., *loc. cit.*, 252.

In the coast districts (especially in sandy soil) from the Cape Peninsula to Port Elizabeth. Type in the Sherardian Herb., Oxford; Herb. Thunberg, Upsala.

Additional records: Tigerberg, Mund and Maire; Swellendam, Jan., O. Kuntze; Riversdale, Dec., Bartlett, 4, Rust, 72; hills near Essenbosch, Dec., Fourcade, 1033; frequent near Assegaibosch, Oct., Jan., Britten, 1237, Schonland, 3624; common in dry rocky ground near Haarlem, Langekloof Valley, c. 2400 ft., Schonland; Port Elizabeth, Paterson, 1890.

(According to the author *Cr. ligulaefolia* Haw. in Misc., 175, and *Cr. concinna* Haw. in Rev. Pl. Succ., 199, resemble *Cr. ciliata* (*ciliare* on the penultimate line on p. 199 is evidently a misprint). These names should be dropped as the flowers are not described, and no originals have been preserved.)

VIRGATA group.

185. **Cr. virgata** Harv. in Fl. Cap., ii, 360; Schonl., *loc. cit.*, 252, and Ann. S.A. Mus., ix, 52.

Hex River, Clanwilliam, Namaqualand, and Little Bushmanland.

186. **Cr. incana** (E. et Z.) Harv. in Fl. Cap., ii, 359; *Cr. pubescens* E. Mey. in Herb. Kew; *Sphaeritis incana* E. et Z. in Enum., No. 1917.

The type represented in Herb. Kew was found between Beaufort West and Graaff Reinet by Drege; on arid hills in the Zwartebergen near Prince Albert, Nov., c. 2600 ft., Bolus, 11874 (Herb. Kew); ? Pearson, 5501, from Nieuwe Rust, Little Namaqualand (Dec., scrambling amongst bushes). The last is close to *Cr. incana*, but probably represents an undescribed species. The stem and leaves are retrorsely papillose.

187. **Cr. subaphylla** (E. et Z.) Harv. in Fl. Cap., ii, 262.

Sphaeritis subaphylla E. et Z. in Enum., No. 1916.

Karroid hills near the Gauritz River, Swellendam, E. et Z. 1916; Zuurberg, near Willowmore, Nov., Bolus, 2303; Matjesfontein, Nov., Purcell; Beremfontein, north of Kl. Zwartebergen, 3800 ft., Andreae 1350; Seven Weeks Poort Mt., north side, 5600 ft., Stokoe 1778, Murraysburg, Tyson, 2831; Clanwilliam, Leipoldt, 532; Enkokerboom, 300 m., Schlechter, 11062.

Var. *puberula* Harv. in Fl. Cap., ii, 362.

Sphaeritis puberula E. et Z. in Enum., No. 1919.

Karroid hills on the Gauritz River, Swellendam, E. et Z. 1919.

The leaves of this species, though usually very short, reach sometimes a length of 2 cm., the length of the internodes varies also. It was placed by Harvey with some other species into the sect. *Margerella* on account of the fact that the channelled point of the corolla becomes solid at the apex.

(*Cr. muricata* Thunb., Prodr., 55, Fl. Cap., ed. Schultes, 283.

This in general appearance is very much like *Cr. subaphylla* (E. et Z.) Harv. in Fl. Cap., ii, 362, and is closely allied to it. It seems to have a similar floral structure, as far as one can judge, without dissection.

In Thunberg's specimens the margins of some (not all) leaves are minutely ciliate. This is the only apparent difference from *subaphylla*, for which Thunberg's name should probably be adopted.)

188. **Cr. Smutsii** Schonl. n. nom.

? *Cr. margaritifera* (E. et Z.) Harv. in Fl. Cap., ii, 262.

? *Sphaeritis margaritifera* E. et Z. in Enum., No. 1913.

Suffruticosa caule efoliato reptanti ascendenti c. 5 mm. crasso. Rami pauci foliati c. 5 cm. longi, pedunculum terminalem c. 15 cm. longum gerentes, teretes glabri pallide virides, internodiis 3–8 mm. longis. Folia grisea glabra vel minutissime pubescentia suberecta subsemiteretia intus subplana extus convexa saepius indistincte carinata ambitu oblanceolata vel oblongo-linearia subacuta, connata, c. 2·75 cm. longa, 5–6 mm. lata. Pedunculus basi viridis superne rubrotinctus minutissime pubescens bractearum vacuorum 2–3 paribus foliis similibus sed multo minoribus instructus. Inflorescentia c. 12 mm. diam. cymoso-capitata trifurcata floribus subsessilibus. Calyx extus pubescens, tubo c. $1\frac{1}{2}$ mm. alto, lobis c. $1\frac{1}{2}$ mm. longis oblongis obtusis turgidis dorso convexis. Petala albida dorso et ad margines puberula panduriformia basi contracta breviter connata apice complicata summo callosa submucronata obtusa c. $2\frac{3}{4}$ mm. longa. Stamina tubo brevi petalorum affixa c. $1\frac{1}{4}$ mm. longa, filamentis brevibus subulatis, antheris filamentis subaequilongis subrectangularibus apice rotundatis luteis. Carpidia c. $1\frac{1}{4}$ mm. longa, ovariis subventricosis in stilum brevem crassum exeuntibus, stigmatis terminalibus. Squamae membranaceae pallide luteae obcuneatae apice rotundatae et leviter emarginatae c. $\frac{1}{4}$ mm. longae.

Amongst grass north of the summit of the Zwarteberg Pass, c. 5000 ft., Dyer, 106 (flowered in Grahamstown, Dec. 1925); ib. Muir, 3783 (flowered at Riversdale, Oct. 1925); Langeberg, on rocks above Waterval, 2500 ft., Sept., Muir, 3712; Zuurberg, near Willowmore, Nov., Bolus, 2303; hills east of Keurbooms River, Langekloof, 3400 ft., Jan., Fourcade, 2497 (flowers yellowish).

I have taken the liberty of naming this plant after the Right Hon. General Smuts, who gave us the pleasure of his company on an excursion to the Zwarteberg Pass in July 1925.

It is almost certainly the plant which Harvey described in the Fl. Cap. as *Cr. margaritifera* (E. et Z.) (*Sphaeritis margaritifera* E. et Z. in Enum., No. 1913), but this name has to be dropped. I have examined a number of specimens placed by Harvey under this species, incl. Drege, 6912, and

E. et Z. 1913, the type of *Sphaeritis margaritifera*, but they all belong to *Cr. mollis* Thunb. (sect. *Globulea*), though they have a great resemblance to *Cr. Smutsii*, which is not known to me, from the neighbourhood of Uitenhage, where E. and Z.'s type came from.

189. **Cr. Purcellii** Schonl. in Rec. Albany Mus., ii (1907), 148.

Matjesfontein, Purcell (flowered in Grahamstown, Dec. 1906); Klein Karroo, Swellendam division, near Hondewater, 2000 ft., Muir, 3819. Type in Herb. Albany Mus.

Dr. Muir sent only one branch, which is more slender than the type from Matjesfontein, with leaves a little less than half the length of Purcell's plants.

The following are notes taken from Muir's specimen :—

About 20 cm. high, laxly leafy, densely covered with short stiff pubescence. Leaves connate, 10–12 mm. long, 5–6 mm. broad, 5–6 mm. thick, adaxial side somewhat flattened. Calyx-tube $\frac{3}{4}$–1 mm. high, calyx-lobes $1\frac{1}{2}$–$1\frac{3}{4}$ mm. long, light green, thick, pubescent, with marginal cilia (cilia short near apex), lanceolate, subacute. Corolla tube 1 mm. high, lobes $2\frac{1}{2}$–3 mm. long, creamy white, glabrous, panduriform, contracted at the base and apex, apical portion not or slightly channelled, strongly keeled on back, terminating in a rudimentary solid slightly recurved mucro. Filaments subulate, 1–$1\frac{1}{4}$ mm. long, anthers elongate $1\frac{1}{4}$ mm. long. Carpels $1\frac{3}{4}$ mm. long, ovaries subumbonate on the back in the upper part, slightly ciliate on inner angle, passing gradually into the very short thick style. Stigmata subterminal. Squamae yellow, obcuneate, slightly emarginate at the apex, about half the length of the carpels.

190. **Cr. serpentaria** Schonl. in Rec. Albany Mus., ii (1907), 149.

Springbokfontein, Namaqualand, Magennis (flowered in Grahamstown, Sept. 1906). Type in Herb. Albany Mus.

This may have to be united with *Cr. Purcellii*, and is chiefly distinguished from it by its extraordinary mode of growth.

191. **Cr. remota** Schonl. in Rec. Albany Mus., i (1904), 118.

Naauwpoort, Dec., Sim, 4. Type in Herb. Albany Mus.

Trachysantha group.

192. **Cr. trachysantha** (E. et Z.) Harv. in Fl. Cap., ii, 362.

Sphaeritis trachysantha E. et Z. in Enum., No. 1915.

Sphaeritis paucifolia E. et Z. in Enum., No. 1914.

Globulea mesembrianthemoides Haw. in Phil. Mag. (1824), 189.

Very common on dry hillsides from the neighbourhood of Port Elizabeth to Linedrift, Peddie district, extending inland to the Fish River Valley.

Judging from a drawing by Haworth at Kew, marked by the unpublished name *Kalosanthes mesembrianthoides* Haw., there is no doubt that his

Globulea mesembrianthemoides is this species, as Harvey already suspected. Moreover, there are specimens in Herb. Lamarck supplied by Haworth. Another drawing at Kew marked *Cr. hispida* Haw. from Bowie's seeds probably also represents this species, but does not show any flowers.

The fleshy apex of the petals is more or less found in several species which have been placed under sect. *Sphaeritis*, and a regular series can be constructed between those in which it is only indicated through those in which it is quite plain (sect. *Margarella* of Harvey) and then to *Cr. trachysantha* (sect. *Pachyacris* of Harvey). These last two sections have, therefore, been dropped. Harvey stated that the fleshy apex is glandular. This is not the case.

TOMENTOSA group.

193. **Cr. tomentosa** Thunb., Nova Acta Nat. Cur., vi (1778), 329, 333, Prodr., 56, Fl. Cap., ed. Schultes, 287 ; Linn. f., Suppl., 170 ; Harv. in Fl. Cap., ii, 360 ; Schonl. in Engl. Bot. Jahrb., xlv, 254 ; N. E. Br. in Gard. Chron., 1903, xxxiv, 152 ; *Sphaeritis tomentosa* E. et Z. in Enum., No. 1920 ; *Turgosea tomentosa* Haw., Rev. Pl. Succ. (1821), 14.

Namaqualand to Laingsburg. E. and Z. also record it from Muizenburg (Cape) and barren hills near the Gauritz River. Thunberg's original specimens, preserved in his Herb. at Upsala, came from Hantum (Hantam Mts. ?). There is a specimen from Riet Valley (Bergius) in Herb. Berol.

Cr. linguaefolia Haw. in Misc. Nat. (1803) = *Turgosea linguaefolia* Haw. in Rev. Pl. Succ. (1821), 14, is, according to the author, closely allied to *Cr. tomentosa* Thunb. and perhaps a variety of it.

Specimens labelled : " Swaziland, Hlatikulu, Miss M. Stewart," in Herb. S.A. Mus., 2624, must evidently be referred to *Cr. tomentosa*. I queried the locality, which seems to me almost certainly to be put down by mistake, but Dr. Phillips insisted that there was no mistake.

Var. *setigera* Schonl. Hairs on leaves longer than in the type. Inflorescences terminal and lateral.

Cr. setigera (E. et Z.) Schonl. in Engl. Bot. Jahrb., xlv, 255.

Sphaeritis setigera E. et Z. in Enum., No. 1921 ; Harv. in Fl. Cap., ii, 361 (sub *Cr. tomentosa*).

On karroid hills near the Gauritz River, Swellendam, 2nd alt., Dec., E. et Z. 1921.

194. **Cr. interrupta** E. Mey., Harv. in Fl. Cap., ii, 361.

Drege (in Herb. Kew), Silverfontein. The following appear also to belong to it : a plant cultivated at La Mortola as *Cr. turrita* ; rocky places on mountain beyond Simonstown, Feb., Schlechter, 331 ; Giftberg, 1000–2000 ft., Sept., Phillips, 7646.

Var. *glabrifolia* Schonl. Surface of leaves glabrous.

Cr. glabrifolia Harv. in Fl. Cap., ii, 361. I have not seen a type of this,

which came from Namaqualand. Specimens sent by Dinter, No. 28 (Quartzberg, near Eindoorn, S.W. Protectorate), which flowered in Grahamstown in Aug. '25, must undoubtedly be referred to it. Except for the leaves being glabrous on the surface, they agree well with *Cr. interrupta.* I append, however, fairly full notes taken from live specimens.

A perennial herb 8·5–20 cm. high. Stem short (not more than 1·5 cm. long), bearing 4–8 pairs of subrosulate leaves. Leaves pale green (the opposite ones distinctly connate), erecto-patent, glabrous on both surfaces, but with long cilia (up to 2 mm. long) on the margin, obtuse, and rounded at the apex, obovate-spathulate, about 18–20 mm. long and 12–20 mm. broad in the lowest portion, distinctly fleshy, slightly convex on the upper surface, a little more so on the under surface. Thyrsus elongate, 7–24 cm. high, bearing 5–9 pairs of bracts which vary in size and shape, but are much smaller than the foliage leaves, though resembling them, the upper ones are coarsely hairy on the back and coarsely ciliate on the margin. They may all have capitate cymes in their axils or the lower ones are empty. The cymes are sessile or stalked, the stalks sometimes reaching 1 cm. in length. The main axis of the inflorescence is red, subangular, lower internodes variable in length (sometimes 3 cm. long), upper gradually smaller. Calyx subtomentose on the outer side, 3·5 mm. long, segments coarsely ciliate on the margin, ovate-obtuse, very convex on the outer side, 2 mm. long. Petals white, much overlapping one another (as always in the section), panduriform, tapering into a plicate point, about 5·5 mm. long, connate at base. Stamens about $\frac{3}{4}$ the length of the petals. Filaments flattened, narrow, white, anthers and pollen yellow. Carpels about 1·5 mm. long, ovary oblong, passing imperceptibly into the short style. Stigmata subdorsal, thick, red. Squamae obcuneate, emarginate at the apex, slightly fleshy, yellow towards the apex, about $\frac{1}{3}$ the length of the carpels.

195. **Cr. scalaris** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 369.

Bullhoek, Clanwilliam, 700 ft., Aug., Schlechter, 8382; east side of Olifants River Valley, near Clanwilliam, on sandstone rocks in shady localities, 75 m., Apr., Diels, 362, in Herb. Berol. (flowers yellowish white). Type in Herb. Albany Mus.

(Judging from a drawing by Haworth at Kew, *Cr. conspicua* Haw. in Rev. Pl. Succ. (1831), 204, belongs to this group and perhaps to *Cr. interrupta,* though Haworth says it is closely allied to *Cr. Cotyledon.*)

NAMAQUENSIS group.

196. **Cr. namaquensis** Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 367.

Garies, Alston; I'aus, on hills, 2300 ft., Schlechter, 11210; Chubiessis, Pearson, 6178; Koets, Pearson, 7221. Type in Herb. Albany Mus.

Var. *lutea* Schonl. in Rec. Albany Mus., i, 117.

Bokkeveld Karroo, 800 m., Oct., Marloth, 3238.

Var. *brevifolia* Schonl. in Engl. Bot. Jahrb., xlv, 253.

Springbokfontein, Namaqualand, Magennis; Richtersveld, 800 m.; Sept., Marloth, 12505.

197. **Cr. tecta** Thunb., Nova Acta Leop. Carol., vi, 1778, 328, 331, Prodr., 56, Fl. Cap., ed. Schultes, 290.

Cr. decipiens N. E. Br. in Gard. Chron., Jan. 1903; Marloth in Das Kapland (1908), 308, fig. 123, A-G; Fl. of South Africa, ii, pl. 5, G.

Middle part of the Little Karroo; Prince Albert, Pearson, 4003/14. Marloth notes that it is rather local in the Laingsburg and Ladismith districts; on stony kopjes near the railway bridge, Oudtshoorn, c. 1050 ft., Apr., Smith, 2795.

This species is very close to *Cr. namaquensis*. The floral structure of the specimens of *Cr. tecta* received from the late Professor MacOwan, which were probably from the same locality as the type of *Cr. decipiens* and which flowered in Grahamstown in March 1904, agreed fairly closely with that of the former, even in such minute details as the occurrence of a red spot between the calyx-lobes, but the upper portion of the petals is not strikingly narrowed and not canaliculate, and the papillae on the leaves are shorter and more truncate. There is a very small but distinct mucro on the petals. In Smith, 2795, one specimen had two lateral branches, each ending in a capitulum on peduncle.

While the majority of Thunberg's specimens of *Crassula* at Upsala are very complete and in magnificent preservation, of this species only two leaves and two useless bits of inflorescences are preserved, but I have no hesitation in identifying it with *Cr. decipiens* N. E. Br.

198. **Cr. hirtipes** Harv. in Fl. Cap., ii, 361.

Near the mouth of the Olifants River, Clanwilliam. Not seen by me.

199. **Cr. hystrix** Schonl. in Engl. Bot. Jahrb., xlv (1910), 256.

Namaqualand, Alston in Herb. Albany Mus.

200. **Cr. biconvexa** (E. et Z.) Harv. in Fl. Cap., ii, 256 (non Haw.); *Sphaeritis biconvexa* E. et Z. in Enum., No. 1918.

Near the Gauritz River, on dry hills. I have not seen a type, but Marloth, 5823, from the Ceres Karroo must be placed here, as it agrees well with the description. At first sight it looks like *Cr. namaquensis* Schonl. et Bak. f. var. *brevifolia*.

(*Cr. biconvexa* Haw., Misc., 176, belongs to the genus *Rochea*, as shown by one of Haworth's drawings at Kew.)

(*Cr.* n. sp. ?

Dinter, No. 10, from Vahldoorn, S.W. Protectorate, appears to be an undescribed species. It belongs to the Namaquensis group of sect.

Sphaeritis. The material at my disposal does not admit of a full description. I have, therefore, preferred not to give it a name yet.

The leaves are about 2 cm. long, obovate or ovate in outline, obtuse or subacute, convex on both surfaces (sometimes more so on the outer surface), very minutely papillose. Inflorescence terminal, pedunculate, trifurcate at the apex, cymules capitate. Calyx pilose.)

SECT. VI. GLOBULEA (Haw.) Harv. in Fl. Cap., ii, 336 ; Schonl. in Engl. Bot. Jahrb., xlv, 244.

201. **Cr. cultrata** L., Sp. Pl., 283 ; Dillenius in Hort. Elth., 115, t. 97, fig. 114 ; Bot. Mag., t. 1940 ; Thunb. in Fl. Cap., ed. Schultes, 288 ; Harv. in Fl. Cap., ii, 363.

Globulea cultrata Haw., Syn. Succ., 60 ; DC., Prodr., iii, 391 ; E. et Z. in Enum., No. 1922.

There is no specimen preserved in the Sherardian Herb., Oxford, on which Dill., Hort. Elth., fig. 114 ("Cr. Anacampseroto foliis" =*Cr. cultrata* L.), is based. There is, however, a specimen in Herb. Linnaeus, London, evidently the same species, named *Cr. cultrata*, and this must be taken as the type. In Thunberg's Herb. at Upsala there are three sheets under this name which are made up of a mixture of species.

Fol. α, two specimens of *Cr. cultrata* L., one of *Cr. Rogersii* Schonl.

Fol. β, a pubescent form which may also have to be referred to *Cr. Rogersii*.

Fol. γ, a form of *Cr. radicans* (Haw.) Harv.

The forms distinguished as α, β, γ in Thunb., Fl. Cap., ed. Schultes, 288, do not correspond to fol. α, β, γ in his Herbarium.

In the neighbourhood of Grahamstown two very distinct forms may be distinguished :

(*a*) *typica*. Leaves glabrous, green, glaucous or with more or less reddish tinge, 3·7–6 cm. long. Shrubby with stout branches.

(*b*) *ramosissima*. Leaves very minutely and more or less densely pubescent, greyish green, about 1·8 cm. long. Irregularly much branched, branches often flexuous.

Olifants River (ex Harvey) ; Tulbagh Kloof, MacOwan ; hills near Humansdorp, 750 ft., Dec., Fourcade, 1029 ; near the Zwartkops River, Z. 2256, 2257, 2258 ; Port Alfred, Schonland ; Grahamstown, MacOwan, 6, 835, and other collectors ; Fish River Valley (Committees, etc.) ; Ripplemead, Kabousie, Nov., Hutton, 505 ; krantzes on Chalumna River, East London division, 25 ft., Dec., Galpin, 6290 ; East London, Rattray, 597.

I have only quoted the specimens which I have at present before me, as in Engl. Bot. Jahrb., xlv, 246, I included (I think now erroneously) *Cr.*

radicans in it. It is, however, a very variable species exhibiting several very divergent growth-forms under different conditions. Harv. in Fl. Cap., ii, 363, has already pointed out the variability of the leaves in shape and hairiness.

In the eastern forms they are usually (though not always) narrower (oblong-obovate) than in those growing further west, and subacute. The branching may only be from the base, and the branches are then simple and upright or it may be very irregular, divaricate, the branches then are often decumbent or ascending, sometimes flexuous ((*b*) *ramosissima*).

The inflorescence may be paniculate with very loose cymules, or sub-corymbose with loose or contracted cymules, or, lastly, we may find a single, terminal, flattened capitulum with a distinct involucre. The plants are generally much more robust and the leaves of firmer texture than in *Cr. radicans*, the size of the flowers and their parts is pretty much the same in both species, but in *Cr. cultrata* the calyx-segments are often pubescent, more obtuse, the expanded part of the petals is broader and entire (not denticulate as in *Cr. radicans*).

202. **Cr. radicans** Harv. in Fl. Cap., ii, 363 (an D. Dietr. in Syn. Pl., ii, 1031 ?). *Globulea radicans* Haw. in Phil. Mag., Nov., 1923; DC., in Prodr., iii, 391 ?; E. et Z. in Enum., No. 1923.

I have followed Harvey in taking Ecklon and Zeyher's specimens from Zwartkops as the type of this species. I must, however, point out that they do not agree with Haworth's original description, from which I quote: "Foliis semiteretibus saepe recurvis supra alta canaliculis." It can hardly be surmised which plant Haworth meant, as no type of his seems to be in existence.

(*a*) *typica* Schonl. The peduncle is glabrous, the leaves glabrous or subglabrous, and the plants have a tendency to form short runners: Near the Zwartkops River, Z. 2552, 2559; saltmarsh near Zwartkops Station, Dec., Britten, 3022; Redhouse, Dec., Paterson, 2206; Aloes, Nov., J. L. Drege, 3133; karroid places near Grahamstown, Nov., MacOwan, 836.

The following notes taken from live specimens collected on the Cradock road, a couple of miles from Grahamstown, will supplement the description in the Fl. Cap.:—

Stem, peduncle, and leaves glabrous, except leaves occasionally with a few cilia on the margin. Calyx-tube $\frac{1}{2}$ mm. long, segments 1–$1\frac{1}{4}$ mm. long, glabrous except for marginal cilia. Corolla tube $\frac{1}{2}$ mm. long, segments 2 mm. long, panduriform, suddenly contracted at the base, minutely and irregularly denticulate in the upper portion, very slightly keeled and shortly pubescent on the back, light yellow when young, turning white on maturity. Filaments 1 mm. long, anthers $\frac{1}{2}$ mm. long. Carpels $1\frac{1}{2}$ mm. long, with very

short style and subdorsal stigma, inner angle minutely ciliate. Squamae yellow, $\frac{3}{4}$ mm. long, obcuneate, rounded and distinctly emarginate at the apex.

(*b*) *Phillipsii* Schonl. Very close to (*a*), but the petals are gradually contracted towards the base (not suddenly as in other varieties and usually in *Globulea*).

Gauritz River, Riversdale division, Oct., Muir, 1792; Mossel Bay, Aug., Rogers, 4336; De Vlugt, Keurbooms River bed and rocks in scrub forest, Uniondale division, 1000 ft., Oct., J. Phillips, 765.

(*c*) *fastigiata* Schonl. More robust than the other varieties, with ascending branches 20–30 cm. long and leaves not subrosulate, in 6–8 pairs, fairly evenly spaced, with internodes about 1–1·5 cm. long. Peduncle terminal, about the length of the leafy basal portion of the branches or longer, with 2 or 3 pairs of small, oblong, obtuse, empty bracts. Leaves glabrous on the surfaces with or without few cilia on the margin, peduncle puberulous, calyx-lobes puberulous on the back, ciliate on the margin. Structure of flower, as in *Cr. radicans*, generally with denticulate petals.

Klein Karroo, 1200 ft., Sept., Muir, 3726.

203. **Cr. fragilis** Schonl. n. sp.

Suffruticosa diffusa 30–75 cm. alta laxe ramosa. Rami ramulique graciles fragiles sublignosi subteretes vel leviter angulati juveniles tenuiter puberuli, rami 2–4 mm. diam., laxe foliati vel basi efoliati internodiis valde variabilibus 0·9–3 cm. longis. Folia viridia tumida leviter connata ambitu oblique oblongo-lanceolata vel oblique lingulata subacuta vel obtusa intus subplana extus convexiuscula utrinque minute puberula usque ad 2 cm. longa. Pedunculi graciles terminales 15–20 cm. longi, ramulis similes sed bracteis vacuis remotis instructi, bracteis foliis similibus sed multo minoribus et saepius acutis 4–7 mm. longis. Inflorescentia terminalis cymosa $\pm$ capitata 1–2 cm. diam., floribus sessilibus vel breviter pedicellatis. Sepala basi connata subplana viridia tubo c. $\frac{1}{2}$ mm. longo, lobis $1\frac{1}{2}$–$2\frac{1}{2}$ mm. longis, linearibus obtusis vel subacutis dorso minute puberulis ad margines ciliatis. Petala alba connata, tubo 1 mm. longo, lobis erectis intus concavis 3 mm. longis, superne ambitu ovalibus inferne valde contractis dorso infra apicem incurvis mucronatis, mucrone globoso vel subgloboso 1 mm. diam. Stamina ad oram corollae tubi affixa filamentis filamentosis $1\frac{1}{2}$ mm. longis, antheris oblongis 1 mm. longis, thecis maturescentibus apice confluentibus. Carpidia 2·5 mm. longa, ovariis oblique oblongis c. 1·7 mm. longis, stilis leviter curvis c. 0·8 mm. longis, stigmatis subterminalibus. Squamae 1·25 mm. longae superne luteae carnosae obcuneatae apice emarginatae.

Sandy dunes at Melkhoutfontein, near sea, 50–100 ft., Oct., Muir, 3782. Type in Herb. Albany Mus.

This species was found by Miss Hortense Muir, who stated that it is almost impossible to handle it without breaking it. Its closest ally is the following.

204. **Cr. Rogersii** Schonl. in Rec. Albany Mus., ii, 149.

Port Alfred, Rev. F. A. Rogers, Tyson, 2226; Redhouse, Nov., Paterson, 2199; neighbourhood of Lake Mentz, Schonland, Dyer; Graaff Reinet, Marchand, 3341/15. Type in Herb. Albany Mus.

Forms with longer leaves than type: Cannon Hill, Uitenhage, MacOwan in Herb. S.A. Mus., Z. 997; amongst rocks in bush, Gwatyn, Queenstown division, 3250 ft., Dec., Galpin, 8334; on rocks overlooking Butterworth River, Oct., Pegler, 2071.

205. **Cr. mollis** Thunb. in Nova Acta Nat. Cur., vi, 1778, 330, 340, Prodr., 55, Fl. Cap., ed. Schultes, 284; L. f., Suppl., 139; Ait. Hort. Kew., 391; Harv. in Fl. Cap., ii, 365; Britten and Baker f. in Journ. of Bot., xxxv, 480.

The type in Herb. Thunberg, Upsala, agrees well with numerous originals of *Sphaeritis margaritifera* E. et Z. which I have examined, all of which belong to sect. *Globulea.*

It is probably the same as *Globulea mollis* Haw. in Phil. Mag., 1824, 191; DC., Prodr., iii, 392.

This was first placed by Haworth in Syn. Plant. Succ., 52, between *Cr. tetragona* and *acutifolia*, but in Phil. Mag., 1824, was removed by him to *Globulea*. Thunberg records it from "Cannaland and Langekloof."

This species resembles *Cr. Smutsii* Schonl. very closely. I have already pointed out that Harvey's *Cr. margaritifera*, in Fl. Cap., 362, has to be dropped as the description does not apply to his type, namely, E. and Z. No. 1913, as far as I have been able to examine it, though possibly Ecklon and Zeyher mixed up two species.

Further, the name *margaritifera* is most inappropriate. I have not seen this character, of which E. and Z. say: "Folia ac caulis saepe absolete [*sic*] margaritifera." I have examined the following in the Herb. S.A. Mus., all of which clearly belong to *Globulea*:

1. In Zeyher's handwriting: 2551 *Globulea*, ♃ (karroo-ähnliche Stellen am Zwartkopsrivier, Januar).

2. In Ecklon's handwriting: 333 *Sphaeritis margaritifera*, ʒ, and printed: on the hills by the saltpan in the 2nd altitude, district of Uitenhage. Fl. December.

3. In Ecklon's handwriting: *Sphaeritis margaritifera* E. et Z. In hiatu supra Zeti, locis lapidosis, Mart., Z. 2549.

4. Printed: 1913 *Sphaeritis margaritifera* (with the information given in Ecklon and Zeyher's Enumeratio).

Drege, 6912, in Herb. Kew.

The following two agree with these specimens :—

Bolus, 12963—In aridis pr. Prince Albert c. 2200 ft., Jan., leg., M. Krige ; Bolus, $\frac{2234}{4}$—Matjesfontein.

On the other hand, there are others which differ more or less from the types in various ways, but which I am not prepared to separate at present, as distinct, not even as varieties.

Paterson, 148, Bethelsdorp, Dec. This is more diffusely branched than the types. The branches and leaves are shorter and thinner.

Muir, 1799. Dry hills near Gauritz River, Riversdale, Sept. This has shorter and relatively thicker leaves than the types. The leaves and branches are very minutely puberulous, but otherwise the plant comes very close to E. and Z.'s specimens.

Smit, Willowmore, Dec. Leaves and branches very densely and shortly puberulous, outline of leaves oblong-linear acute.

Christy, 58, Humansdorp. Leaves in outline oblanceolate, margin ciliate.

The following notes are taken from Muir, 1799, which grows in erect clumps :—

Suffruticose, richly branched from near the base, branches suberect, slender, subterete, very minutely pubescent, c. 30 cm. long, distinctly leafy throughout. Lowest internodes 6–8 mm. long, upper longer (up to 2·4 cm.), though unequal. Leaves glaucous, semiterete, oblong lanceolate, acute, minutely pubescent, lowest 1·8 cm. long, gradually decreasing upwards, uppermost 4 mm. long, minutely ciliate on the margin. Inflorescence terminal subcorymbose, ultimate inflorescences capitate, few-flowered. Bracts similar to the upper depauperated leaves of the branches but a little smaller. Sepals united at the base, sublanceolate, very obtuse at the apex and gibbose dorsally below the apex, 1·75 mm. long. Petals 2·2 mm. long, yellowish white, similar to allied species with a thick oblong mucro behind the apex, suddenly cqntracted in the lower portion, forming a small tube at the base. Stamens attached tc corolla tube, c. 1·5 mm. long. Carpels 1 mm. long, stigma subsessile, subdorsal. Squamae pale orange, almost as long as the ovary, membranous, obcuneate with the upper corners rounded off.

206. **Cr. obvallata** L., Mant., 61 ; DC., Pl. Gr., t. 61 ; Harv. in Fl. Cap., ii, 247 ; Schonl. in Engl. Bot. Jahrb., xlv, 247.

Cr. torquata Bak. in Saunders' Ref. Bot., iii, t. 154.

Cr. obfalcata Hort. (ex DC.) ; *Cr. obvallaris* Hort. (ex Haw.) ; *Cr. lanceolata* Hort. Plant. Paris. (ex DC.).

Cr. subacaulis Schonl. et Bak. f. in Journ. of Bot., xxxvi (1898), 370.

Globulea obvallata Haw., Syn. Pl. Succ., 60.

? *G. capitata* E. et Z. in Enum., No. 1924 (an *Gl. capitata* Haw., Rev. Pl. Succ., 17 ?).

? *G. paniculata* Haw. in Phil. Mag., 1825, 29; DC., Prodr., iii, 392. (Some authors have erroneously quoted a *Cr. capitata* Salm-Dyck in Cat. Hort. Dyck., 1820, 14. Salm-Dyck has not published such a species.)

Very widely distributed in the coast districts of the Cape Province from Namaqualand to Kentani, and penetrating inland in the eastern parts to the highest mountains and the O.F.S.

Specimens not mentioned in Engl. Bot. Jahrb., xlv, 247:

Stinkfontein, Namaqualand, Pearson, 5590; Bakhuis Karroo, Pearson, 5486; Van Rhynsdorp, 80 m., Diels, 454 and 510; Rudersheim, Hay district, Wilman; ? Capetown, Paterson, 72; Karatara, Knysna, 900 ft., Dec., Keet, 1138; rocky places at base of Knysna Heads, Dec., Schonland, 3407; Jagersbosch, near Avontuur railway line, Sept., Schonland, 3075; dry hillsides, Assegai Bosch, Jan., Schonland, 3634*a*; 3 miles N.W. of Keiskama Hoek, 3000 ft., Sept., Dyer, 125; Katberg, 3500–4000 ft., Oct., Dyer; Basutoland, Dieterlen, 806, in Herb. S.A. Mus.; Hillandale, Bloemfontein, 4800 ft., Nov., Potts, 2066.

The following notes were taken from Dyer, 108, which seems to be a fair average type of this somewhat variable species: Margin of leaves only ciliate at and near the base. Calyx-tube $\frac{1}{2}$ mm. long, lobes $2\frac{3}{4}$–3 mm. long, linear, green, ciliate margined, otherwise glabrous, slightly concave within, with thick, obtuse apex. Corolla tube 1 mm. long, lobes 3 mm. long, panduriform, contracted at the base, with thick obovate subapical mucro, white above, light green and minutely glandular-pubescent on back, upper margin sometimes with one or few minute lacerations. Filaments slender, subulate, 2 mm. long, anthers $\frac{3}{4}$–1 mm. long. Carpels 2 mm. long, with short, thick style and subdorsal stigma, very minutely fringed with hairs on inner surface. Squamae obcuneate, emarginate at the top, yellowish, with pink tip.

We have specimens (hills near Gauritz River, Riversdale division, Nov., Muir, 1828) which, as far as leaves, flowers, and inflorescence are concerned, are similar to the robust forms of *Cr. obvallata*, which have been described as *Cr. torquata* Bak., to which I also refer, *e.g.* Pegler, 1842, from Kentani. As in DC., Pl. Gr., t. 61, the ascending stem has distinct internodes at the base, while the youngest leaves are subrosulate. Stem and peduncle are thicker and evidently more fleshy than in the ordinary forms.

207. **Cr. platyphylla** Harv. in Fl. Cap., ii, 363.

I have not seen the type of this species, but I doubt whether it is justifiable to keep it separate from *Cr. obvallata*. I place under it a number of specimens agreeing with the description in having subrosulate quite glabrous,

obtuse, rarely subacute leaves. A few deviations from Harvey's description will be noted.

Phisantefontein in Klein Karroo, 1200 ft., Nov., Muir, 3809 (leaves punctate, with a fine waxy bloom. Leaves slightly over 2 in. long. In this and the two following the leaves are not flat); Springfontein, Klein Karroo, Riversdale division, 1200 ft., Oct., Muir, 3784; Matjesfontein, Sept., Purcell; Seekoogat, Stormberg, 5000 ft., Dec., Sim (calyx-lobes distinctly ciliate on margin, very sparingly hairy or glabrous on the back. Otherwise this specimen agrees best with the description of the type); Majuba Nek, Herschel district, Jan., Hepburn, 170 and 270 (leaves about 1¼ in. long, only about ⅜ in. in greatest width), calyx-lobes pubescent on back and ciliate on margin; ? Bloemfontein, Feb., Potts, 240 (specimen poor); Fauresmith Bot. Reserve, Smith, 4429.

208. **Cr. cephalophora** Thunb. in Nova Acta Nat. Cur., vi, 1778, 333, Prodr., 55, Fl. Cap., ed. Schultes, 285; L. f., Suppl., 190; DC. in Prodr., iii, 388; Britten et Bak. f. in Journ. of Bot., xxxv, 480. Type in Herb. Thunberg, Upsala.

Cr. cotyledonis Thunb. in Nova Acta Nat. Cur., vi, 1778, 328, 330, Prodr., 56, Fl. Cap., ed. Schultes, 289, also preserved in Herb. Thunberg.

Cr. canescens Roem. et Schultes, Syst., vi, 374; Harv. in Fl. Cap., ii, 364.

Cr. dubia Schonl. in Engl. Bot. Jahrb., xlv (1910), 248.

Cr. Tayloriae Schonl. in Engl. Bot. Jahrb., xlv (1910), 248.

Cr. Rehmanni Bak. f. in Bull de l'herb. Boiss., iii, 2 ième série (1903), 817, t. 9 (mala ?).

Globulea canescens Haw., Syn. Succ., 61; DC. in Prodr., iii, 391; E. et Z. in Enum., No. 1926.

This species has canescent leaves; the length of the hairs varies. There is also a fair amount of variation in the size and shape of the leaves. Occasionally it has a lateral inflorescence in addition to the terminal one, an unusual feature in species of sect. *Globulea.*

(*a*) *Thunbergii* Schonl. Leaves lanceolate sublinear or oblanceolate oblong, obtuse or subacute.

Redhouse, Oct., Paterson, 804, in Herb. Albany Mus., an excellent match of Thunberg's type of *Cr. cephalophora*; Walmer, Oct., Paterson, 804*a*; 24-Rivers, Oct., Miss Du Plessis.

(*b*) *Tayloriae* Schonl. (*Cr. Tayloriae* Schonl., *Cr. cotyledonis* Thunb., *Cr. Rehmanni* Bak. f.). Leaves obliquely obovate, contracted into a cuneate base. Distinctly canescent.

Stellenbosch, Jan., Broom; Smith, 2716*a*, c. 850 ft., Mar., Worcester; Ladismith, Dec., Marloth; common in the Klein Karroo, Muir, 3820; Oudtshoorn, Dec., Taylor, 2; sandy places near the Zwartkops River, 1st

alt., Jan., E. and Z., No. 1925 (sub *Cr. obvallata*) and Z. 2555 ; Aloes, near Port Elizabeth, Nov., J. L. Drege, 3120.

(*c*) *dubia* Schonl. (*Cr. dubia* Schonl.). Leaves broadly obovate, slightly oblique, with a short cuneate base.

A common form on rocky slopes near Grahamstown (Rogers, 133, Daly, 1048).

(*d*) *basutica* Schonl. Leaves obovate 3–4 cm. long, minutely puberulous.

Leribe, Basutoland, Jan., Dieterlen, 418*b*, p. pte. in Herb. S.A. Mus.

The following notes were taken from Muir, 3820 :—

Perennial herb, about 30 cm. high, with basal leaves. A short piece of the stem efoliate. Leaves and peduncle densely covered with short, stiff retrorse pubescence. Leaves connate, 1·8–3·25 cm. broad, 4–10 mm. thick, with short retrorse cilia on margin. Lower surface slightly convex, upper concave or slightly convex. Peduncle terminal with several pairs of empty bracts, bearing in the upper portion a series of subglobose cymules, the lower ones of which are stalked, the upper sessile. Calyx-tube $1\frac{3}{4}$ mm. long, lobes $\frac{3}{4}$–1 mm. long, ligulate, obtuse on the outside with comparatively long but not dense pubescence. Corolla tube 1 mm. long, lobes $2\frac{1}{4}$ mm. long, cream-coloured, contracted at the base with a large ovoid subterminal mucro, puberulous on the outside. Stamens about 2 mm. long, filaments filiform, anthers oblong. Carpels with short style and subdorsal stigma, $1\frac{1}{2}$ mm. long, with a few hairs on the inner angle. Squamae yellow, subquadrate, $\frac{1}{4}$–$\frac{1}{2}$ mm. high, $\frac{1}{2}$ mm. broad.

Comparing this with notes on (*c*) (*Cr. dubia*), I find that apart from the shape of the leaves, here the calyx-tube is shorter, the petals sometimes larger and often in the middle pale green, but none of these characters would induce me now to keep it up as a separate species. It has, like Muir, 3820, a minute pubescence on the back of the petals which has not been looked for in other specimens belonging to *Cr. cephalophora*. It is a very uncommon character in the genus. As in *Cr. obvallata* and *Cr. radicans* the petals are sometimes minutely and irregularly denticulate in the upper portion, as is also the case in *Cr. erosula* N. E. Br.

209. **Cr. Rattrayi** Schonl. et Bak. f. in Journ. of Bot., xl, 1902, 290.

In the original description the leaves were described as glabrous. This is a mistake, they are minutely pubescent. Since its publication a number of specimens have come to hand. These show that *Cr. Rattrayi* has a fairly wide distribution. Very often it is decidedly more pubescent than the type, in which case the technical characters separating it from *Cr. cephalophora* become very shadowy. Very often it is slightly branched above the base, and each branch then bears a subrosulate cluster of spathulate or obliquely spathulate leaves rarely exceeding 3 cm. in length. The

inflorescence is more delicate than in *Cr. cephalophora*, but the difference cannot be expressed in hard and fast terms.

Graaff Reinet, Rattray, 30 (type in Herb. Albany Mus.); Cradock, Oct., Murray; Baroda, R. A. Dyer; Fairford, Cathcart division, Oct., Cotterell, 45; Laingsburg, Marloth, 2512 (has much lower inflorescence than in type); *ibid.*, Marloth, 2511; Grootkraal, Cango East, Oudtshoorn division, Oct., Deas, 8; hills at Van Wyk's Dorp, 1400 ft., Sept., Muir, 3719; De Doorns, Jan., Bolus, 13101; Worcester, common on karroid veld near the town, Sept., Schonland (connects with *Cr. cephalophora* Thunb.).

210. **Cr. erosula** N. E. Br. in Kew Bull. (1903), 300.

Little Namaqualand: on gravel slopes in Doornpoort Ravine, Pearson, 6153. Type in Herb. Kew (a cultivated specimen with elongated internodes).

As the author has stated, it is closely allied to *Cr. canescens* R. et S.

A specimen collected on hills at Waterval, Riversdale division, 1500 ft., Sept., Muir, 3725, agrees well with the description of *Cr. erosula*, except that it does not seem to have denticulate petals. On the whole, apart from the fact that the leaves are glabrous, it agrees also very closely with a number of specimens which I have placed under *Cr. Rattrayi*.

211. **Cr. Fergusoniae** Schonl. n. sp.

Herbacea perennis carnosa. Radix fusiformis. Caulis brevis e basi ramosus. Folia opposita, 4–6, subrosularia, connata, carnosa, pubescenti-canescentia, ambitu obovato-cuneata vel oblonga apice obtusa vel subacuta truncata, intus plana extus convexiuscula, exteriora c. 1·4 cm. longa, c. 1·1 cm. lata, interiora breviora et angustiora. Inflorescentia thyrsoidea, pedunculo rubro tereti pubescenti subflexuoso c. 4·5 cm. longo, bracteis vacuis 0 vel 2 oppositis instructo, thyrso compacto vel laxo 1·5–8 cm. longo, c. 8 mm. lato, cymis capitatis floribus subsessilibus. Calycis-tubus brevis, lobis navicularibus obtusis dorso pubescentibus, ad margines ciliatis, vix 2 mm. longis. Petala c. 2·2 mm. longa albida leviter luteo-tincta basi connata panduriformia inferne contracta dorso infra apicem mucronata, mucrone crasso ambitu subovato. Stamina ad faucem tubi corollae affixa, c. 1·6 mm. longa, filamentis albis angustis applanatis c. 0·7 mm. longis, antheris anguste ovatis luteis. Carpidia c. 1·4 mm. longa ovariis oblique oblongis, stilis brevibus stigmatis subdorsalibus. Squamae obcuneatae c. 0·4 mm. longae.

Phisantefontein in the Klein Karroo, Riversdale division, 1200 ft., Aug., Muir, 3667; hills at Van Wyk's Dorp, Ladismith division, 1400 ft., Sept., Muir, 3724; Deerde River, Riversdale division, 1200 ft., Sept., Muir, 3720.

As in allied species, the rather thick style passes imperceptibly into the ovary and the stigma is obliquely placed at the end.

forma major. Ad 25 cm. alta, internodiis distinctis, inflorescentia magis ramosa.

Hills at Van Wyk's Dorp, 1400 ft., Sept., Muir, 3719.

Specimens collected by me at Worcester, Sept. 1910, appear to connect this form with *Cr. cephalophora* L. f. They have somewhat longer and relatively narrower leaves than the type of *Cr. Fergusoniae*, which at first sight resembles *Cr. namaquensis* var. *brevifolia*.

212. **Cr. clavata** N. E. Br. in Kew Bull., 1914, 167.

Prince Albert division, Pearson. Type in Herb. Kew.

A dwarf species, about 4 cm. high, with radical rosulate leaves, which are rhomboid-clavate, obtuse, glabrous, glaucous green, punctate. Inflorescence terminal, bearing a small capitulum.

The author says "species ab omnibus distinctissimus." From an inspection of the original (without, however, dissecting the flowers) and the minute description by the author, I would conclude that it belongs to sect. *Globulea* and might be placed near *Cr. Fergusoniae.* Against this view is Mr. Brown's statement that the squamae are minute, whereas usually in *Globulea* they are very conspicuous. It is interesting that the flowers, according to the author, are pentamerous or hexamerous. I have never seen this variation in sect. *Globulea.*

213. **Cr. nudicaulis** L., Sp. 405 ; Dillenius, Hort. Elth., t. 98, fig. 115 ; DC., Pl. Gr., t. 133 (evidently drawn from a specimen grown in a damp atmosphere) ; Harv. in Fl. Cap., ii., 364.

Globulea nudicaulis Haw., Syn. Pl. Succ., 61 ; DC., Prodr., iii, 391 ; E. et Z. in Enum., No. 1927.

The type of this species in the Sherardian Herbarium, Oxford, has quite glabrous leaves and scape and, therefore, *Cr. sulcata* D. Dietr. in Syn. Pl., ii, 1031, Harv. in Fl. Cap., ii, 364 (=*Globulea sulcata* Haw. in Rev. Pl. Succ., 18 ; DC., Prodr., iii, 391 ; E. and Z. in Enum., No. 1928), must be referred to it. In Herb. Lamarck at Paris the scape and leaves are slightly pubescent. In fact pubescent and glabrous forms cannot be separated even as varieties, they may be found side by side (*e.g.* in Britten, 5558). The species is found in the coast districts from Clanwilliam (or Namaqualand ?) to the Bathurst division, but seems to have a somewhat disconnected distribution.

? Klippfontein, 2nd alt., Z. ; Clanwilliam to Boschkloof, Drege (ex Harvey) ; sand dunes near Capetown, E. and Z. 1827 ; Rietvalley (1816), Bergius in Herb. Berol ; Riversdale, Rust, 297 ; mountains near the Koude River, 800 ft., Dec., Schlechter, 9742 ; on the Zwartkops River, in the 1st alt., E. and Z., No. 1828; Three Sisters, 10 miles east of Port Alfred, Britten, 5558.

214. **Cr. hirta** Thunb. in Fl. Cap., ed. Schultes, 284.

This species is closely allied to *Cr. nudicaulis* L., but its conspicuously albo-hispid leaves make it desirable to keep it up. It is represented in Thunberg's Herb. at Upsala (with leaves barely 3 cm. long) and by specimens collected during recent years (often with longer leaves): Welgevonden, Riversdale division, 600 ft., Oct., Muir, 2396 (this shows some of the empty bracts on the scape arranged in fours, a most unusual character, also seen in Dillenius' fig. of *Cr. nudicaulis*); Albertinia commonage, Riversdale division, Oct., Muir, 1798.

I append the description of Muir, 1798:

Perennial herb, c. 30 cm. high. Roots long, slender. Stem ascending, thickened at the efoliate base, sparingly branched. Leaves subrosulate, suberect, lanceolate-subulate, soft, semiterete, slightly channelled on the upper side, connate vaginate, 6–9 cm. long, 4–8 mm. broad, either covered all over with retrorse white setose hairs (which are arranged in small groups) or only in lower part, while upper part is only sparsely hairy. Inflorescence terminal, thyrsoid, or paniculate, with subglobose cymules. Peduncle c. 25 cm. long, terete, pubescent, with 1–3 pairs of empty bracts. Bracts ovate-lanceolate, acute, connate-perfoliate, lowest up to 2·2 cm. long, upper c. 8 mm. long, tomentose. Floral bracts green, ciliate on margin, 3 mm. long. Sepals united at the base, lobes similar to the bracts but obtuse, c. 2 mm. long. Petals white with a yellowish-green tinge, almost free, panduriform, contracted at the base, with a thick subglobose dorsal mucro below the apex. Stamens adnate to the short corolla tube, c. 1–1¼ mm. long, with filiform filaments. Carpels c. 1½ mm. long with obliquely oblong ovaries, short, thick styles and subdorsal stigmata. Squamae pale orange coloured, membranous, obcuneate, a little emarginate at the apex, c. 0·8 mm. long.

Var. *Dyeri* Schonl. (*an nova sp.* ?).—About 10 cm. high. Leaves not more than 2 cm. long, subligulate, obtuse or slightly acuminate, slightly convex on both surfaces, which are covered, except at the base and margin, with tufts of short, white, retrorse hairs; margin surrounded by a horny line with minute, stiff, retrorse cilia. Peduncle slender, suberect, with 4 pairs of empty sublanceolate bracts, which are about 3 mm. long, the upper distinctly retrorsely ciliate on the margin. Flowers in a few-flowered subcapitate cyme.—Mode of growth and details of flowers as in the type.

Grahamstown flats, R. A. Dyer in Herb. Albany Mus.

215. **Cr. spicata** Thunb. in Nova Acta Nat. Cur., vi, 1778, 329, 333, Prodr., 55, Fl. Cap., ed. Schultes, 254; L. f., Suppl., 189; *Purgosea spicata*, Don, Gen. Syst., iii, 105.

The type of this species is preserved in Herb. Thunberg, Upsala. It was placed by Thunberg next to *Cr. hirta*, and, like it, it seems to belong to sect. *Globulea* (although placed by de Candolle under *Turgosea*). The description in Thunberg's Fl. Cap., 254, is quite good as far as it goes. The

fact that the dense opposite cymules more or less coalesce to form verticillasters and that these are more or less crowded together makes the inflorescence very characteristic, simulating a spike.

(*Cr. subincana* D. Dietr. in Syn. Pl., ii, 1031; *Globulea subincana* Haw. in Phil. Mag., 1824, 190, is represented at Kew by one of Haworth's drawings. It is unrecognisable. There are no flowers. The vegetative organs are similar to those of *Cr. acutifolia.*

Cr. Lingua D. Dietr., *loc. cit.*; *Globulea Lingua* Haw., *loc. cit.*, is also represented at Kew by one of Haworth's drawings and is also unrecognisable.

Cr. Lingula D. Dietr., *loc. cit.*; *Globulea Lingula* Haw., *loc. cit.*, is unknown to me. The last two must, however, most likely be placed under *Cr. obvallata L.*

Cr. atropurpurea D. Dietr., *loc. cit.*; *Globulea atropurpurea* Haw., *loc. cit.*, 189, is according to the Ind. Kew =*Cr. portulacea*, but according to Haworth's drawing at Kew it seems to belong to *Cr. obvallata* L.

Globulea hispida Haw. in Phil. Mag., 1824, 191; *Cr. hispida* D. Dietr. Syn., pl. ii, 1031 (unknown to me); see, however, *Cr. hispida* Haw., on p. 267.

SECT. VII. PYRAMIDELLA Harv. in Fl. Cap., ii, 336; Schonland in Engl. Bot. Jahrb., xlv, 244.

216. **Cr. columnaris** Thunb. in Nova Acta Nat. Cur., vi (1778), 335, Prodr., 57, Fl. Cap., ed. Schultes, 291; DC., Prodr., iii, 385; Harv. in Fl. Cap., ii, 358; Burmann, Dec. Afr., 19, t. 2; Marloth in Das Kapland, 227, figs. 884 and 306, fig. 122, 2, Flora of South Africa, ii, pl. v, E and figs. 10, 11, 7; Schonl. in Engl. Bot. Jahrb., xlv, 250; Cannon, Vegetation of the more arid portions of Southern Africa, Washington, 1924, pl. 29, B; Wettstein, Handbuch d. syst. Botanik, 2. Aufl., 644; *Cr. semiorbicularis* E. et Z. in Enum., No. 1890.

In Thunberg's Herb. at Upsala there are three typical specimens and two approaching the form named by E. and Z. *Cr. semiorbicularis.* The type is also represented in the Linnean Herbarium, London.

A typical specimen of *Cr. columnaris* collected by Thunberg is in Herb. Jacquin at Vienna; in the same collection is a specimen c. 12 cm. high which has more the growth of *Cr. semiorbicularis* E. et Z.

Cr. semiorbicularis E. et Z., which agrees with MacOwan, 3204 (collected by E. G. Alston in stony places near Garies, Namaqualand, Sept. 1897) appears to be only a growth form of *Cr. columnaris.* The upper leaves on the elongated stem are much depauperated, the lower closely imbricated. Other specimens collected by Mr. Alston in Namaqualand have elongated stems with leafy pairs fairly evenly distributed, the upper being slightly smaller than the lower. A quite abnormal form is represented by a specimen

in the Berlin Herbarium collected by Drege (*Cr. columnaris* β *elongata* E. Mey.) in which the inflorescence is rather loose, thyrsoid, about5 c m. long.

217. **Cr. congesta** N. E. Br. in Gard. Chron. (1902), ii, 171; Pole Evans in Fl. Pl. of South Africa, t. 115. Type in Herb. Kew.

Cr. pachyphylla Schonl. in Rec. Albany Mus., i (1903), 58, Engl. Bot. Jahrb., xlv, 257.

Western Karroo—additional record: 13 miles from Touws River, 2000 ft., Sept., Muir, 3708.

I have already pointed out (Engl. Bot. Jahrb., xlv, 257) that this species may have lateral inflorescences in addition to the terminal one. This I have only seen in specimens from Matjesfontein. The leaves may be quite obtuse, very thick, ovate in outline, subhorizontal, or they may be sublanceolate acute and deflexed, but transitions between these extremes are found.—*Cr. laticephala* Schonl. in Rec. Albany Mus., ii, 457, was collected by Mr. Volschenk near Riversdale. In the original account I pointed out the close relationship to *Cr. congesta*. Specimens received later, collected at the same locality by Mr. Volschenk, were indistinguishable from the acute-leaved form found at Matjesfontein. The flowers were equal in size and the squamae, which in the type of *Cr. laticephala* are broader and have much shorter stipes than the Matjesfontein forms, were narrower and had long stipes. I therefore sink *Cr. laticephala* in *Cr. congesta*.

218. **Cr. teres** Marl. in Trans. Roy. Soc. S. Afr., iii (1913), 122, pl. viii, fig. 4.

Sand-river Mts., near Prince Albert, flowered in Capetown, May 1912, Marloth, 4446.

A dwarf species which, as the author has pointed out, is similar in shape to *Cr. pyramidalis*, but with leaves more like *Cr. columnaris*. It is quite possible that this is a hybrid. I have seen a robust form from Whitehill, near Matjesfontein, which could be described briefly in similar terms. This certainly gave one the impression of being a hybrid.

219. **Cr. Barklyi** N. E. Br. in Kew Bull., 1906, 19. The author is now of opinion that this should be united with *Cr. teres* Marl., which I am not prepared to accept. The type in Herb. Kew, found in Little Namaqualand, shows stem (with leaves) forming an oblong, not a subterete structure. The chief difference seems to be in the flowers, judging from the measurements given by the authors:

Cr. Barklyi.	*Cr. teres.*
Sepals $1\frac{1}{3}$–$1\frac{1}{2}$ lin. (c. 2 mm.) long; linear-spathulate, obtuse, glabrous, ciliolate.	3 mm. long; linear with a broad hyaline margin.
Petals: tube 2 mm. long, lobes 5 mm. long.	Tube 3 mm. long, lobes 10 mm. long.

220. **Cr. cylindrica** Schonl. n. sp.

Herbacea carnosa 8·5 cm. alta. Caulis cum foliis columnam subcylindricam 1·5–2 cm. diam. formans. Folia quadrifaria dense imbricata carnosa subplana dorso canaliculata, 10–12 mm. lata, 5–10 mm. longa, late triangularia apice subacuta, marginibus leviter incurvis, inferne pallide viridia, superne saturate viridia cerifera, superiora ad margines papilloso-ciliata. Inflorescentia terminalis sessilis multiflora subsemiglobosa, 3·5 mm. diam., floribus sessilibus suaveolentibus pallide luteis. Tubus calycis 1 mm. altus, lobi 3 mm. longi linguaeformes obtusi virides superne turgidi, ad margines minute ciliati. Tubus corollae 3·25 mm. altus, lobi 7 mm. longi lineares obtusi recurvi. Stamina tubum corollae affixa 3 mm. longa, filamentis filiformibus, antheris oblongis. Carpidia 2 mm. longa, ovariis oblique oblongis, stilis quam ovaria brevioribus leviter recurvis, stigmatis terminalibus. Squamae e stipite gracili sursum cuneatim dilatatae superne brunneae 1·5 mm. longae.

Found sparingly at Coega, 13 miles from Touws River, Worcester division, 2000 ft., Sept., Muir, 3709. Type in Herb. Albany Mus.

221. **Cr. pyramidalis** Thunb. in Nova Acta Nat. Cur., vi, 1778, 336, t. 5*b*, Prodr., 56, Fl. Cap., ed. Schultes, 287; Burmann, Dec. Rar. Pl. Afr., t. 9, fig. 3; Linn. f., Suppl., 189; DC., Prodr., iii, 388; Harv. in Fl. Cap., ii, 358; Burbridge in Gard. Chron. (1872), 289, fig. 208, and (1885), i, 545, fig. 101; Hook. f. in Bot. Mag., t. 7665; Schonl. in Engl. Bot. Jahrb., xlv, 257; Cannon, Vegetation of the more arid portions of Southern Africa, Washington, 1924, pl. 28 (wrongly named *Cr. columnaris*); Marloth, Fl. of South Africa, ii, fig. 7, A; Wettstein, Handbuch der syst. Botanik, 2. Aufl., 644. *Cr. quadrangula* Endl. (ex Walp. Rep., ii, 253).

Tetraphyle pyramidalis and *T. quadrangula* E. et Z. in Enum., No. 1863, No. 1864.

Namaqualand and Karroo eastwards to Stormbergen. In Engler's Bot. Jahrb. I pointed out already that forms similar to Bot. Mag., t. 7665, are only known to me from the eastern parts of its area of distribution (*e.g.* MacOwan, 472, E. and Z. 1863, Sim, sine No., from the Stormbergen). Already near Willowmore it is more elongated and may bear short branches (similar to Marloth, Das Kapland (1908), 226, fig. 88, I).

There are also forms which are divaricately branched and remind one very much of the robust forms of *Cr. lycopodioides* Lam., and I may here remark that this species, although placed in a different section, leads up to *Cr. pyramidalis*. Already Thunberg had remarked in his Fl. Cap., 288, that the latter is allied to his *Cr. muscosa*, which is the species now known as *Cr. lycopodioides*. The much-branched form of *Cr. pyramidalis*, reaching a height of about 15 cm., is found near Matjesfontein. Mr. Volschenk sent it also (with somewhat smaller flowers than usual) from Riversdale.

The leaves seem to be always slightly connate, though Hooker insists that in his specimens they were free. He further states that they are puberulous on the margin. This is also found in the upper parts of the leaves of the other forms, but not as a constant character. Contrary to expectation, I found that the branched form is the type as represented in Herb. Thunberg at Upsala. We find this also in Herb. Jacquin, Vienna, where the specimens reach a height of 18–20 cm. Several forms seem to be constant under cultivation, and the separation of these, at all events as varieties, may be desirable.

222. **Cr. alpestris** Thunb. in Nova Acta Nat. Cur., vi, 1778, 319, 336, t. 5*b*, fig. 4, Prodr., 55, Fl. Cap., ed. Schultes, 285; Linn. f., Suppl., 189; DC., Prodr., iii, 387; Britten et Bak. f. in Journ. of Bot., xxxv, 485; Schonl. in Engl. Bot. Jahrb., xlv, 258.

Cr. multiceps Harv. in Fl. Cap., ii, 359.

Cr. Massoni Britten et Bak. f., *loc. cit.*

Cr. variabilis N. E. Br. in Kew Bull., 1901, 132.

Cr. spicata Herb. Jacquin (non Thunb.).

In Thunberg's Herb. at Upsala there are two sheets, both named by Thunberg *Cr. alpestris*.

Fol. α has three specimens which agree with *Cr. Massoni* Britt. et Bak. f. This name has to be dropped. I look upon these specimens as types. *Cr. alpestris* Harv. in Fl. Cap., ii, 341, is quite a different plant and has been rightly renamed by Britten et Bak. f. (see p. 212).

Fol. β contains three scraps, at first called *capitella*, but this name has been crossed out and *alpestris* substituted. These do not belong to *Cr. alpestris*, and may belong to *Cr. corymbulosa* Link et Otto.

The species is not uncommon from Namaqualand to Clanwilliam and from Worcester to Matjesfontein. It is very variable (Mr. N. E. Brown himself has sunk his *Cr. variabilis* into *Cr. Massoni* in the Kew Herb.). It ranges from dwarf specimens not more than 2·5 cm. high to about 20 cm. The margins of the leaves may be altogether ciliate or the cilia may be restricted to the base. The stem may be simple or richly branched near the base, subdichotomously branched in the upper portion. The inflorescence is capitate, subcorymbose or thyrsoid. All three forms are *e.g.* represented in Schlechter, 8663. The following notes, taken from live specimens, will supplement the published descriptions :—

Leaves connate, from a triangular base lanceolate acute, margin of the base ciliate (this is the case also in Z. 660, Harvey's type of *Cr. multiceps*), lanceolate, upper part thickened. Flowers white with a strong sweet scent. Calyx-tube $\frac{1}{2}$–1 mm. long, lobes 3–3$\frac{1}{2}$ mm. long, ciliate or subglabrous on the margin, sublinear, slightly broadened in upper part, obtuse, membranous below, thickened towards the apex. Corolla tube 2$\frac{1}{2}$ mm. high, lobes some-

what boat-shaped, linear, narrowing slightly upwards, obtuse. Stamens attached to the mouth of the corolla tube or just below it, filaments filiform, $\frac{1}{2}$–1 mm. long. Carpels only slightly broadened near the base, acute angled towards the centre, glabrous, $3\frac{1}{4}$ mm. long. Styles short, thick, ovaries passing imperceptibly into them. Stigmata terminal. Squamae pale pink, flat, narrow below, broadened out, rounded or slightly emarginate at the apex, less than $\frac{1}{2}$ mm. long.

(Thunberg has pointed out in Fl. Cap., ed. Schultes, 286, that this species is very similar to *Cr. montana* L. He gives the differences between them, but to my mind they are not at all closely allied.)

223. **Cr. vestita** Thunb. in Nova Acta Nat. Cur., vi, 1778, 329, 335, Prodr., 56, Fl. Cap., ed. Schultes, 290; DC., Prodr., iii, 385; Linn. f., Suppl., 188; Harv. in Fl. Cap., ii, 366.

This species is represented in Thunberg's Herbarium at Upsala by two specimens, unfortunately, as far as I could see, without flowers. One is about 18 cm. high, the other about 6 cm. The branches are incurved or recurved and (with the covering leaves) 3–3·5 mm. in diam. The plants have somewhat the appearance of *Anacampseros ustulata*, though they are larger and thicker. They were found in very dry, stony places in the Onderste Roggeveld.

Dr. Marloth made a description from live specimens from which most of the following notes were compiled. They were found growing on flat rocks near Sutherland and flowered at Capetown in November (Marloth, 9808).

Perennial herb with weak and decumbent branches, the lower part bare or bearing withered leaves, the upper thickly covered with imbricating 4-ranked leaves, 8–9 mm. wide on the wild plant, but more slender and elongated under cultivation. Leaves connate and perfoliate, glabrous, punctate, covered with a white powder, each about 4 mm. long, each pair forming a rhomboid body with two obtuse points, there being no indentation at the junction of the leaves, margin not papillose-ciliate. Cymes terminal, capitate, sessile, 8–20-flowered, 9–12 mm. in diam. Sepals slightly connate, ovate, obtuse, fleshy, thickened near the apex, whitish on the outer side. Corolla $2\frac{1}{2}$–$2\frac{3}{4}$ mm. long, tube $\frac{1}{2}$ mm. long; petals erecto-patent, lower part broadly ovate, boat-shaped, the upper narrowed to an obtuse, slightly channelled recurved point, cream-coloured but with a few scattered red specks on the back of the recurved point. Stamens a little shorter than the petals, anthers just exserted at the mouth. Carpels somewhat slender, $2\frac{1}{4}$ mm. long, the ovaries passing gradually into the styles. Stigmata small, capitate, terminal. Squamae subquadrate, slightly emarginate above, $\frac{1}{2}$–$\frac{3}{4}$ mm. long.—The short channelled point of the petals and subquadrate squamae do not fit in too well with sect. *Pyramidella*, yet I am at a loss to place this species anywhere else.

Species not recognised and not mentioned in the text, on which no suggestion can be offered :

Cr. atrosanguinea B. H. B. (1907), 1013, ex Kew Bull., 1908, App. 84.

Cr. diffusa (Soland.) in Ait. Hort. Kew., ed. 1, i, 395.

Cr. diffusa Willd. in Linn. Sp. Pl., ed. 4 (1798), 1564.

Cr. imbricata Burm. f., Fl. Cap. Prodr., 8.

Cr. obtusa Haw., Suppl. Pl. Succ., 16.

Cr. rotundifolia Haw. in Phil. Mag., Sept. 1824. According to de Candolle in Prodr., iii, 395, this is *Kalanchoe rotundifolia* Haw. (in Taylor, Phil. Mag., No. 327, 1825, 31), but Haworth does not mention *K. rotundifolia* in his account of Kalanchoe in Rev. Pl. Succ., 1831. I have not seen the paper quoted by DC. Harv. in Fl. Cap., ii, 379, says that he is uncertain whether this is Haworth's species of *Cr.* or not. I do not see how it can be.

The following do not belong to the genus *Crassula* (in addition to others mentioned in the text. See Index) :—

Cr. capillacea E. Mey. (Dinacria).

Cr. chloraefolia D. Dietr. (Grammanthes).

Cr. coccinea Linn. (Rochea).

Cr. Ecklonii D. Dietr. (Grammanthes).

Cr. filiformis D. Dietr. (Grammanthes).

Cr. fruticosa Mill. (Euryops).

Cr. jasminea Ker (Rochea).

Cr. jasminiflora Haw. (Rochea).

Cr. media D. Dietr. (Rochea).

Cr. odoratissima Andr. (Rochea).

Cr. pinnata L. f. (Bryophyllum).

Cr. portulacastrum Harv. (Portulacaria).

Cr. Portulacaria Linn. (Portulacaria).

Cr. retroflexa Thunb. (Grammanthes).

Cr. versicolor Burch. (Rochea).

INDEX.

PRELIMINARY REPORT ON THE TOXICITY OF THE FRUIT OF *MELIA AZEDARACH* (SYRINGA BERRIES).

By D. G. Steyn and M. Rindl.

From the Department of Pharmacology and Toxicology, Veterinary Research Laboratories, Onderstepoort, Pretoria, and the Department of Chemistry, Grey University College, Bloemfontein.

Melia Azedarach, Linn. (Fam. *Meliaceae*), also known as China tree, Chinese umbrella tree, China berry, Pride of India, is a tree growing to a height of 40 feet and more and making a thick trunk with furrowed bark. The ripe drupe is nearly globular, yellow, and smooth, $\frac{1}{2}$ to $\frac{3}{4}$ inches in diameter. The tree is native to the Himalayan region, where it is found to an altitude of 2000 to 3000 feet, and is now widely planted as an ornamental tree. In South Africa it is known as Bessiboom, Sering, or Syringa, and the fruit is commonly called Syringa berry.

The recorded information with regard to the toxic nature of the fruit of this plant is conflicting.

In a number of experiments made by H. C. Wood * with extracts from the dried fruit and bark, it was found impossible to poison frogs or rabbits. Robins eating of the sweetish fruit, of which they are very fond, are often rendered so far insensible as to be picked up under the tree; though they usually recover after a few hours. Children are said to eat the fruit without inconvenience, and possibly the robins simply choke themselves with the large berries.

On the other hand, several cases are reported in this country where the death of children is ascribed to poisoning by syringa fruit.

A fatal case of poisoning with the berries of the Cape Syringa tree (*Melia Azedarach*) occurred at King William's Town in 1910. Some tests were accordingly made in the Grahamstown Laboratory. Twenty-five berries, powdered and subsequently boiled to a thick gruel, were administered to a healthy sheep without any effect whatever. Seventy-five berries, similarly prepared, produced no noticeable effect on a healthy calf, nor did fifty-one berries on a young, healthy dog.†

* U.S. Dispensatory, XX ed., 1215.

† Report of the South African Association for the Advancement of Science, 1914, p. 124.

Lander * records that hogs have been poisoned in Arizona by ignorant feeding of the seeds. Two cases are quoted of New South Wales farmers,† who maintain that they have lost pigs from poisoning by these berries. In one case four pigs died, and on post-mortem a lot of the berries (called white cedar berries) were found in the stomach, which was inflamed. Another farmer lost two out of three pigs that had ingested these berries. The symptoms are described as follows: Soon after ingestion the animals became very ill, being unable to stand or move, heart beating feebly, occasional spasmodic shudderings, and limbs cold.

The results of the earlier feeding tests carried out at the Veterinary Research Laboratories at Onderstepoort were negative throughout. In 1908 one horse and one mule were each fed with 20 lbs. of drupes mixed with bran, during a period of five days with no evil effects. In the same year two cows fed with 4 lbs. of the fruit mixed with 4 lbs. of bran appeared unaffected. In 1910 two sheep were fed with 2½ lbs. of the fruit, again without deleterious effects.

In 1925, on the initiative of Sir Arnold Theiler, the problem was again taken up. An ox and three sheep were fed at regular intervals for a period of approximately a fortnight, again without evidence of the animals being affected.

In view of the inconclusive nature of the recorded evidence, and prompted by the persistent popular belief with regard to the toxicity of the fruit and the periodical reports of alleged poisoning, both of human beings and animals, it seemed desirable to reinvestigate the problem both from the toxicological and chemical point of view.

The botanical information was kindly furnished by Dr. E. P. Phillips of the Division of Botany, Pretoria.

Feeding Tests.

As stated in the introduction, all previous experiments with syringa fruit on domestic animals were carried out either by feeding the fruit mixed with lucerne, bran, etc., or by feeding the fruit as such. As the drupes have a peculiar, unpleasant smell and an intensely bitter, nauseating taste, it is quite natural that animals, especially those accustomed to kraal- or stall-feeding, would not consume them, in whatever form they may be presented. Although this is the general rule with plants endowed with an unpleasant taste and a repulsive smell, we often find individual cases of animals eating such plants. This explains the fact that the evidence given by farmers concerning the ingestion of these drupes by pigs is so conflicting.

* Veterinary Toxicology, 1926, p. 203; also Pammel, Manual of Poisonous Plants, p. 121.

† Agr. Gazette of New South Wales, 1897.

In the experiments at the Onderstepoort Laboratories none of the animals (guinea-pigs, rabbits, muscovy ducks, sheep, goats, and pigs) would ingest the material which was given as such, and subsequently mixed with different foodstuffs, *e.g.* bran, meal, lucerne, etc. Pigs, even after a starvation period of four days, were still unwilling to take crushed mealies mixed with a small amount of ground syringa fruit. Drenching by means of a stomach tube was then resorted to, as this method of experimenting with poisonous plants furnishes the most reliable information, although for different reasons it is not always practicable.

As the fruit contains a large amount of resin which renders grinding in the moist state impossible, it had to be air-dried, and the doses quoted in the undermentioned experiments refer to this dried material containing approximately 12 per cent. of moisture.

Rabbits.

The m.l.d. of the dry berries for rabbits varies from 4 to 6 grams per kilogram body-weight. One to one and a half hours after lethal doses had been administered the animals became very restless, jumping about in the cage and shaking the head. This preliminary stage of excitement soon passed over into the paralytic stage, the animals being unable to keep the head up. Later on the animals were totally paralysed, lying stretched out on the side and unable to move. The heart-action in the stage of excitement was very rapid but still strong ; later on, however, it became extremely weak and accelerated, and was imperceptible prior to death.

During the stage of excitement the respiration was deepened, accelerated, and costoabdominal, and as death approached it became more and more superficial and was of a more abdominal type. In the paralytic stage the animals often gasped for breath, dying in a state of complete paralysis and suffocation. Cyanosis of the mucous membranes was very distinct before death.

Lethal doses varying from 5 to 8 grams per kilogram body-weight caused death within two to three days, and in a few cases even within a few hours after drenching. In these sub-acute cases the animals showed in addition to the above symptoms a marked foetid diarrhoea.

Larger doses caused death within $1\frac{1}{4}$ to $2\frac{1}{2}$ hours after dosage, the most outstanding symptoms being complete paralysis, irregular respiration, both in respect of depth and frequency, and very marked symptoms of suffocation. In many cases the animals were markedly bloated before death.

Post-mortem Appearances.—The blood in all cases, even hours after death, showed only partial coagulation, and was of an intense dark-reddish colour. In the less acute cases the lesions varied from a slight acute catarrhal

to a marked acute haemorrhagic gastro-enteritis. There was a marked general cyanosis, as well as a hyperaemia of the liver and lungs. The heart was either in diastole and markedly distended with semi-coagulated blood masses, or in systole. In cases where bloating was pronounced the pyloric muscles of the stomach were found to be in a state of complete spasm. In the per-acute cases there was a hyperaemia of the gastro-intestinal mucosa, the rest of the post-mortem being identical with that described in the sub-acute cases.

Dogs.

It was impossible to kill dogs with syringa berries, as these animals vomited within two to three minutes after having been drenched, most probably owing to the irritating effect the fruit exerts on the gastric mucosa. They refused food and remained apathetic for twelve to twenty-four hours, but ultimately recovered.

Sheep.

A sheep drenched at 11 a.m. with 800 grams of fruit developed symptoms within three hours after dosage. The animal was lying down and very apathetic, although it sometimes got up and walked very fast for a short distance, only to lie down again. Symptoms of excitement appeared periodically.

When forced to rise its movements were very sluggish, and it immediately went down again. The conjunctivae were at first dark reddish in colour, and later on turned purplish. The heart-action, which at first was accelerated but strong, was later on almost imperceptible and very much accelerated. The respiration was laboured, being increased both in depth and frequency. During the course of the following night the animal died.

Another sheep dosed with the same quantity of fruit died under identical symptoms within fourteen hours after dosage.

Post-mortem Appearances.—There was a marked general cyanosis. The blood, although the interim in both cases was about six hours, was only partly coagulated and of an intense dark-reddish colour. The subcutaneous blood-vessels, especially those of the front-quarters, were markedly injected with blood. In cases where animals were post-mortemed within an hour after death the blood simply flowed off from the skinned surface.

Furthermore, there was a fatty degeneration of the liver, tumor splenis, a marked general swelling of all the lymph glands, and a pronounced catarrhal abomasitis and enteritis, chiefly affecting the small intestine.

Goats.

A goat drenched with 200 grams of fruit showed no effects of poisoning. Three days later it received 400 grams, also with a negative result. After

another fourteen days it received 800 grams of material, and developed symptoms of poisoning within half an hour after dosage. The animal was very restless, running about, stamping and scratching with the feet, moving the head up and down, lying down and again rising after an interval of a few seconds. Occasional clonic spasms of the diaphragm were very distinct, and it was during these contractions that the animal showed the most marked signs of distress and gasped for breath. Three and a half hours after dosage the animal was lying down, groaning and very apathetic. At irregular intervals it gasped for breath. The respiration was very irregular both in depth and frequency, double expiration occurring at irregular intervals. The pulse was very weak and fast, but regular. The animal was also markedly bloated. The next morning after dosage the condition of the animal was slightly improved, and on the third day complete recovery had taken place.

Eight days later this goat received 1000 grams of drupes per os. The symptoms described above started half an hour after drenching and increased in severity. The following morning the animal was lying down and unable to rise, and when picked up it was unable to stand. This paralytic effect was most marked in the hind-quarters. In addition fibrillary contractions of the muscles of the hind-quarters were very distinct. Later on the animal developed a bilateral purulent conjunctivitis. As this paralytic stage persisted for a period of seven days the animal was killed for post-mortem purposes.

Post-mortem Appearances.—The following lesions were present: Dilatation of the right ventricle, a bilateral purulent conjunctivitis, a fibrinous pleuritis, broncho-pneumonia, oedema of the mucous membrane of the abomosum, trichuris ovis in large intestine, stilesia hepatica with cirrhosis of the liver, cysticercus tenuicollis cysts, and an abnormal amount of fluid in the spinal canal. In addition the animal showed a small ulcerating wound at a previous point of injection with an alcoholic extract of the drupes.

Pigs.

The m.l.d. for pigs weighing about 75 kilograms varies from 150 to 200 grams of the drupes. A pig weighing 75 kilograms, which received 200 grams of the material per os, developed symptoms within half an hour. The animal was very restless, performing retching movements; later on actual vomition occurred. Symptoms of dyspnoea were marked, the animal frequently gasping for breath. The conjunctivae were bluish in colour, the pulse weak and accelerated, and the respiration laboured and irregular. Two and a quarter hours after dosage the animal died in a state of convulsions and suffocation.

Another two pigs died with similar symptoms $1\frac{1}{4}$ hours after having received 200 and 300 grams respectively of material per os. In addition these animals were markedly bloated before death.

Post-mortem Appearances.—The post-mortem revealed a marked general cyanosis, the stomach markedly distended with gas and hyperaemia of the mucosa, and congestion of the liver.

Subcutaneous Injections.

Guinea-pigs.

The injections were carried out with evaporated 96 per cent. alcoholic extracts, as alcohol proved to be the best solvent for the toxin (or toxins).

The subcutaneous m.l.d. per 500 gram guinea-pig of this extract varied from 5 to 10 grams of the air-dried drupes.

Immediately after the injection the guinea-pigs were very restless and were biting at the point of injection owing to the irritating nature of the injected material. This irritation may have been, at least for the greater part, caused by the relatively large amount of acid present in the evaporated extract. If the animals survived the injection for a few days extensive necrosis of the subcutaneous tissues surrounding the point of injection took place.

Two to three hours after the injection of a lethal dose the animals became very apathetic, and when the cage was touched or any noise made the whole body, especially the front-quarters, fell into convulsions, which lasted a few seconds. The respiration was very superficial, slow, and spasmodic. The symptoms increased in severity, and four to seven hours after injection, sometimes earlier, spontaneous convulsions occurred at regular intervals of one to two minutes. In some cases bloating was very marked. The animals continually gasped for breath, and died under signs of suffocation from ten to twenty-four hours after injection. Bigger doses caused the same train of symptoms and proved fatal within an hour after injection.

Post-mortem Appearances.—In cases where the animals died within a period of an hour or so after large subcutaneous doses, the only lesions were a very marked general cyanosis and an intense dark-reddish discoloration of the blood, which, even hours after death, was only partly coagulated.

In less acute cases the port-mortem revealed a pronounced general cyanosis, dark-reddish discoloration of the blood, gelatinous infiltration at the point of injection, hyperaemia and sometimes emphysema of the lungs, heart generally in diastole, marked hyperaemia of the liver, and a pronounced acute catarrhal gastro-enteritis, the stomach being distended with gas and the pyloric muscles in a state of spasm.

Rabbits.

The subcutaneous m.l.d. of the alcoholic extract varied from 3 to 5 grams per kilogram body-weight. Apart from the subcutaneous oedema at the point of injection, the symptoms and post-mortem appearances coincided with those observed in rabbits drenched by means of a stomach tube.

Pigs.

A pig, weighing 100 kilograms, which was injected subcutaneously with extract equivalent to 200 grams of the fruit, showed a passing stage of somnolence and developed a warm, painful oedema at the point of injection. A week later another 200 grams equivalent of fruit was injected subcutaneously, the animal dying fourteen hours after injection with symptoms and post-mortem lesions similar to those described in fatal cases drenched per os.

Another pig (weight 80 kilograms) succumbed to the syringa fruit toxin within fourteen hours after a single subcutaneous injection equivalent to 200 grams of air-dried fruit.

Microscopical, Pathological, Anatomical Diagnosis.

The sections were prepared and examined in the Department of Pathology of the Onderstepoort Laboratories.

Fatty degeneration and hyperaemia were present in the liver and kidneys. One sheep showed a Lymphadenitis purulenta diffusa acuta, and the goat, which was killed on account of the paralysis, showed a degeneration of the sciatic nerve.

Are other Domestic Animals susceptible to the Syringa Toxin ?

The first-named author was informed verbally that donkeys were seen to have ingested the fruit while grazing under syringa trees at Pretoria North, but showed no signs of having been affected. Assuming the m.l.d. of the drupes for sheep to be 800 grams, then at least 3000 grams would be required to cause death in a donkey, unless this species of animal is abnormally susceptible to the poison. It is hardly imaginable that a donkey would ingest such an amount of the fruit with its bitter and nauseating taste.

Four muscovy ducks were force-fed daily with 30 grams of fruit for a period of three days without any ill effects. These experiments are, however, to be continued as soon as this season's drupes have ripened.

It is maintained that different kinds of wild birds are very fond of the

syringa fruit, but they are said to ingest only the outer, softer portion of the fruit and to discard the kernels. Another point to be investigated is the locus of the toxin, *i.e.* whether it is contained in the outer fleshy portion of the fruit only, or in the kernel only, or in both.

The Toxicity of other Parts of the Tree.

1. *Green Leaves.*—Quantities up to 60 grams administered in one dose had no effects on rabbits.

2. *Bark.*—Quantities up to 15 grams had no effect, whereas 60 grams killed rabbits within $1\frac{1}{4}$ days. Cornish * reports the presence of a bitter alkaloid to which he has given the name " margosine." This alkaloid is credited with antiperiodic virtues. It does not appear to have been chemically characterised.

3. *Young Flowers.*—15 grams had no effect, while 60 grams killed rabbits within five days after dosage. The symptoms correspond to those caused by the fruit.

The Nature of the Toxic Principles.

Before the chemical investigation was entered upon the presence of a toxic alkaloid was suspected. Preliminary experiments on rabbits were, therefore, carried out with tannic acid, on the assumption that the tannic acid would form with the supposed alkaloidal poison an insoluble or sparingly soluble compound, which would be absorbed only very slowly, or not at all.

The dried fruit was ground very finely and macerated with tap water. To this suspension different amounts of tannic acid (varying from 0·5 to 4·0 grams) were added immediately before dosage. The quantities of plant material drenched to rabbits varied from 15 to 60 grams. An amount of 0·5 gram of tannic acid, added to 15 grams of fruit, prevented symptoms and death. The control rabbits, drenched with 15 grams of fruit only, died. Quantities of tannic acid up to 4 grams per rabbit had no effect when doses exceeding 15 grams were administered.

As the toxic substance subsequently proved to be of a non-alkaloidal nature, the beneficial action of the tannic acid in the case of the lethal dose of 15 grams may be due to one of the following causes :—

(*a*) The astringent action of the tannic acid on the gastro-intestinal tract and the consequent decrease in the rapidity of absorption.

(*b*) The formation of an insoluble or sparingly soluble product.

(*c*) The formation of an innocuous compound possibly of the nature of an ester or acid anhydride.

* Ind. Ann. Med. Sci., iv, 104, quoted in U.S. Dispensatory, XXI ed., 1215.

The Action of the Poison on the Animal Body.

Judging from the symptoms which the fruit induced in the different species of animals experimented upon, there seems to be no doubt that the toxic substance is of a narcotic nature, attacking the whole central nervous system, although, as previously stated, the paralytic stage is preceded by a preliminary stage of excitement. These symptoms of excitement are most pronounced in the goat. The toxic principle (or group of principles) also has an irritating effect on the gastro-intestinal mucosa, since even on subcutaneous administration an acute catarrhal gastro-enteritis developed.

The fact that the toxic substance in lethal doses causes paralysis of the central nervous system, and that the animals die in a state of suffocation gasping for breath seems to justify the conclusion that death is ultimately caused by paralysis of the centre of respiration.

Chemical Investigation.

Preliminary.—A small amount of the ground material was extracted with alcohol, and tested in the usual way for alkaloids, with negative results. Similarly hydrocyanic acid was proved to be absent. The reaction of the extract is acid.

The ground material was mixed with an equal weight of 96 per cent. alcohol and allowed to stand for several days with periodical shaking. The process was repeated with the same quantity of alcohol, and after separating the alcoholic extract, an amount of the solid residue equivalent to 50 grams of fruit was tested for toxicity on a rabbit by drenching by means of a stomach tube. As the animal displayed no unusual symptoms, it appears that the toxic principles can be completely extracted by cold alcohol.

Thermostability of the Toxic Principle.—Fifty grams of dried material were extracted for a day by continuous hot percolation with alcohol, furnishing, after removal of the solvent, 12·3 grams of resinous extract. This resin was treated with a small amount of alcohol, only part of it going into solution. A quantity of solution equivalent to 10 grams of drupes proved fatal to a guinea-pig twelve hours after subcutaneous injection, whilst half the quantity caused death after eighteen hours. Similar results were obtained on repetition. As 5 to 10 grams had been established as the m.l.d. for a 500 gram guinea-pig, the poison has apparently not lost any of its virulence as a result of continuous heating.

Selective Solubility of the Active Constituents.

Fifty grams of the ground, air-dried material was extracted in succession by continuous hot percolation with the following solvents :—

Petroleum ether (70–75° C.) extracts	2·48	grams
Ether	0·35	„
Chloroform	0·22	„
Ethyl acetate	8·65	„
Alcohol	5·88	„
Total	17·85	grams

The ground material contained about 12 per cent. of moisture, hence the amount of moisture extracted by organic solvents is equivalent to 40·6 per cent. calculated on the weight of absolutely dry material. These extracts are designated in the subjoined summary of results of the injection tests as Group I.

The petroleum ether extract is a light yellow oil with a rancid smell, and is devoid of poisonous properties.

The ether extract has the same smell as the petroleum ether extract when hot. Part of it is a thick viscous brown resin, and part is of the nature of a brittle varnish. It is sparingly soluble in cold alcohol and is toxic, the total amount (equivalent to 50 grams of fruit) killing a guinea-pig within twelve hours after subcutaneous injection.

The chloroform extract is a pasty brown mass which dissolves slowly in cold alcohol. The extract (equivalent to 50 grams of fruit) killed a guinea-pig twenty-seven hours after subcutaneous injection.

The ethyl acetate extract is a brown resin which has, apparently, become altered by continuous heating. After extraction it is sparingly soluble both in ethyl acetate and alcohol, whereas the unheated resin is readily soluble in the latter solvent. Injected into a guinea-pig it produced no effect.

The alcohol extract is a thin, viscous yellow resin, the solubility of which has also been materially reduced by continuous heating. It is physiologically innocuous.

None of the above extracts contained anything of a crystalline nature. The exhausted residue, weighing something over 30 grams, was administered to a rabbit and proved to be no longer poisonous.

It appears, therefore, that the toxic principles are all contained in the ether and chloroform extracts, which represent roughly 1·3 per cent. of the weight of the original dry material.

Are the Toxic Principles extracted by Ether and Chloroform Different?

The fact that the ether and chloroform extracts did not produce markedly different symptoms on a guinea-pig suggests that the toxic principles contained in these two extracts might be identical. It was considered possible

that the ether-soluble poison might be so sparingly soluble as to require several days of hot percolation for exhaustion, and that the subsequent chloroform extract may then prove to be non-toxic.

Two Soxhlets, each containing 25 grams of finely ground material, were therefore set up, and, after exhaustion with petroleum ether, were extracted consecutively with two different lots of ether, the extraction being continued about a day in each case.

Extract A from both Soxhlets	0·24 gram
Extract B ,, ,, ,, ...	0·10 ,,

The total amount (0·34 gram) is the same as that previously obtained (0·35 gram) in one extraction. Extract A killed a guinea-pig six hours after subcutaneous injection, whilst extract B proved fatal within twelve hours. A guinea-pig injected with the chloroform extract survived. These extracts are designated as Group II.

As will be seen from the summary of the results of the injection tests with the ether and chloroform extracts given below, there are such wide differences in the susceptibility of different animals that it was not considered safe to draw conclusions from a single negative result. Moreover, there was a possibility that the positive result obtained in the first instance with the chloroform extract may have been due to decomposition products derived from the solvent used for extraction.

It had previously been established that ether extracts owed their toxicity, at least in part, to impurities of an acid nature (formic acid ?) contained in the ether.

A new lot of material (275 grams) was, therefore, extracted, using specially purified ether and Merck's anæsthetic chloroform. The ether was purified by shaking with a concentrated calcium chloride solution to remove traces of alcohol, dried over calcium chloride, and distilled over solid caustic soda. These extracts are subsequently designated as Group III.

Ether extract.

An amount equivalent to 20 grams of fruit killed a guinea-pig within twelve hours.

,, ,, to 5 grams had no effect.

Chloroform extract.

First series—

Amount equivalent to 40 grams killed guinea-pig within fourteen hours.

,, ,, to 15 grams had no effect.

Second series of injections with material from same extraction—

Amount equivalent to 40 grams killed guinea-pig in five hours.

,, ,, to 15 grams had no effect.

In all cases alcoholic solutions were used for injection purposes, and blank tests were carried out with pure alcohol. It was found that a guinea-pig will stand up to 4 c.c. of 96 per cent. alcohol without marked effect.

Summary of Results of Injection Tests.

Ether.		Chloroform.	
Equiv. to grams of fruit.	Death supervened.	Equiv. to grams of fruit.	Death supervened.
Group I 50 .	12 hours	50	27 hours
Group II 50 .	6 ,,	50	not fatal
Group III—			
Series I 20 .	12 ,,	40	14 hours
,, I 5	not fatal	15	not fatal
Series II . .	..	40	5 hours
,, II . .	..	15	not fatal

As the material had been exhausted with ether before extracting with chloroform, there would appear to be little doubt that at least two different toxic principles are present. The negative result in the case of the chloroform-soluble portion of Group II. is most probably attributable to individual idiosyncrasy of the test animal. In view of the wide variations in susceptibility, as shown in the above summary, no useful purpose can be served at this stage by expressing the toxicity of the extracts in figures. Moreover, the extracts are probably mixtures of toxic principles with innocuous compounds.

Nature of the Toxic Principles.

The ether extract is slightly bitter and contains only a trace of nitrogen. Both alkaloids and proteins were tested for, with negative results. In the case of the latter, the Biuret and Millon's reactions were definitely negative, whilst the Xanthoproteic reaction was indefinite on account of the yellow colour of the extract. The toxic substance is soluble both in hot and cold alcohol and in boiling water, and these facts, taken in conjunction with the negative results of the protein reactions, rule out a compound of the nature of a toxalbumin. The extract does not reduce Fehling's solution, even after prolonged heating on the water bath with dilute hydrochloric acid. It is, therefore, apparently not glucosidal.

The chloroform extract has a persistent bitter taste and contains no nitrogen. It is, therefore, not of the nature of an alkaloid or a protein.

Attempts to hydrolyse it with dilute hydrochloric acid were negative, as in the case of the ether extract. Since the poisonous principles are not alkaloids, glucosides, or proteins, they most probably belong to that indefinite group known as " bitter principles."

The ether extract appears to be more toxic than the chloroform extract.

Experiments are at present in progress with the object of obtaining the active principles in larger quantities and of preparing them in a pure form. So far, however, it has been impossible to isolate homogeneous products. The causes of the inhibitory effect of tannic acid are also under investigation.

Summary and Conclusions.

1. Hogs, sheep, goats, rabbits, and guinea-pigs are susceptible to the syringa poison, pigs being the most susceptible animals, and goats less so than sheep.

2. Muscovy-ducks were not killed even by relatively high doses of the plant material.

Dogs vomited immediately after being drenched, and although they showed symptoms of poisoning, they recovered after a period of several hours.

3. The symptoms produced in the fatal cases are paralysis and narcosis. Death usually occurs through suffocation. Irritation of the gastro-intestinal tract is also evident, even when the administration is subcutaneous.

4. The toxic substance is thermostable.

5. Cold alcohol completely removes the poison from the ground fruit, but the product is contaminated with considerable quantities of innocuous resin. By continuous hot percolation with ether, followed by chloroform, the poisonous principles can be extracted in a purer form.

6. Although the ether and chloroform extracts do not give rise to markedly different physiological symptoms when injected into guinea-pigs and rabbits, the fact that continuous extraction with ether fails to completely extract the toxic substance, makes the existence of at least two different principles probable.

In this connection it might be pointed out that guinea-pigs and rabbits very often show the same train of symptoms when dosed or injected with extracts of different plants. These animals appear to be useless in the differential diagnosis of most plant poisons.

7. The toxic principles are not of the nature of alkaloids, toxalbumins, or glucosides easily hydrolysed by acids. They most probably belong to that indefinite group known as " bitter principles."

8. Attempts to obtain homogeneous products have so far proved abortive.

9. The addition of tannic acid to doses not exceeding 15 grams has an inhibitory effect.

The investigation is being continued.

The last-named author is the holder of a Union Government Research grant, part of which was used to defray the expenses of the investigation. He also desires to place on record his indebtedness to the Director of Veterinary Services for permission to carry out part of the chemical investigation at the Laboratory for Veterinary Education and Research at Onderstepoort, and for the facilities placed at his disposal. The authors also tender their thanks to Dr. H. H. Green for valuable suggestions and advice.

ON *BACILLUS FULMINANS* AND CERTAIN OTHER NEW ORGANISMS ISOLATED FROM *XENOPUS LAEVIS*.

By Th. Schrire and Emily C. Greenfield.

(From the Bacteriology Department of the University of Cape Town.)

An abscess accidentally discovered in the pectoral muscles of a frog (*Xenopus laevis*) which was being used in the course of experimental work, provided the material from which the organisms described in this communication were isolated.* The abscess was found embedded in the muscles ; its walls were thick and soft, and it contained thick yellowish pus.

A smear of the pus contained in the abscess was made and stained with Gram's stain. Large, Gram-positive bacilli occurring in long chains were observed. They differed from anthrax bacilli in that their edges were rounded and the chains did not resemble the " bamboo-canes " so typical of anthrax. The cellular constituents of the pus were very much broken up, apparently by the action of the organisms, but as far as could be seen they were entirely leucocytic. Phagocytosis could not be seen.

Another smear of the same pus showed, in addition, several small cocci as well as some rather small bacilli. These, however, were in very small numbers, and could only be found after the careful search of several fields.

The pus was inoculated on to plates of agar-agar, blood-agar, and MacConkey's medium, these being most readily available. The plates were incubated at room temperature (20° C.) for twenty-four hours and were then examined. No growth appeared on the MacConkey plate, but on the agar-agar a rather luxuriant growth was seen. Four types of colonies were observed, and were picked off and sown on to fresh agar slopes. The colonies were called " P," " Q," " R," and " S." Those of " P " were large, rhizoid, and spreading. " Q's " were minute and were picked off with the aid of a lens. " R's " colonies were dew-drop in form ; only one or two of this type were available, and these were picked off. The plate on which they were sown, however, remained sterile and they were thus lost. " S's " colonies were white, paint-like, and rather small ; they grew quite well on agar-agar.

The bacteria described in this paper are, therefore, " P," " Q," and " S." It will be shown that " P " is probably the exciting cause of the abscess.

* The authors are indebted to Dr. D. Epstein, of the Pharmacology Department of this University, for the material from this abscess.

Cultural Characters.

Organism "*P.*"

The organism is a large, thick, non-motile rod. It varies in length from 3·5 to 8·0 microns, and in breadth from 0·75 to 1·25 microns. It produces spores abundantly, these being formed rapidly, in eighteen hours at 34° C. The spores are somewhat broader than the vegetative forms, and they swell the bodies of the bacilli slightly when formed. The cell itself degenerates when a spore is formed, and the latter often carries a small tag of protoplasm for some time. Ultimately, in seven-day agar cultures it is very difficult to find any vegetative forms at all, the spores adhering to the vegetative forms' positions and appearing in long chains.

The dimensions of the spores are much more constant than those of the bacilli. In form they are oval, and they vary in length from 1·5 to 2·0 microns, and in breadth from 0·75 to 1·0 microns. They are difficult to stain, but once coloured they retain the stain very well. They were stained with hot Ziebl-Neelsen, differentiated in alcohol and 1 per cent. sulphuric acid, and counterstained with watery methylene-blue (Muir's method). The spores stain red and the bacilli themselves blue.

The variations in size of the vegetative forms may be ascribed to the finding of the bacilli in various stages of division. The ends of the cells are rounded or convex, in marked distinction to the majority of anthrax forms described, which have sharply cut-off or even concave ends. Certain individuals show vacuoles; these are usually Gram-negative, and the vacuoles are manifestations either of degenerative phenomena or of a presporulating condition.

The organisms stain well with carbol-fuchsin, methylene-blue, and are strongly Gram-positive.

Agar colonies of twenty-four hours' growth at 37° C. averaged 5·0 mm. in diameter. They were greyish-white, spreading and rhizoid; the edges were slightly indented and the surfaces rough, being somewhat smoother towards the centre.

Agar colonies growing below the surface of the medium (in "shake" cultures) were seen to be composed of loosely interlacing threads which were, in their turn, composed of long chains of bacilli. While being reminiscent of anthrax, the colonies had a far more loose arrangement, there being no tendency towards the formation of a compact central mass.

Growth on agar slopes was greyish, coarsely granular, spreading, and fimbriate; on taking this up in saline the whole growth came away in one piece, like a sheet of parchment. Agar stabs showed growth along the line of inoculation, with a more abundant surface expansion.

On gelatin plates the colonies were white, also resembling the " Medusa Head " of anthrax, but being also more loosely arranged. They were situated in the centre of a small saucer-shaped zone of liquefaction which appeared within twenty-four hours. In gelatin stabs liquefaction is crateriform and regular, commencing within twenty-four hours and proceeding to completion.

Broth shows a thick pellicle, which is formed in forty-eight hours and is easily dislodged, a greyish powdery sediment and a clear supernatant fluid.

In peptone water growth is abundant. A heavy sediment is formed, and a pellicle is seen in two to three days. Indol is formed.

Nitrate medium shows a heavy pellicle and a coarsely flocculent deposit which clings to the sides of the tube throughout the medium. These flocculi form a sediment, and are found in great abundance at the bottom of the tube. The nitrates are reduced to nitrites.

Litmus-milk is completely decolorised in twenty-four hours, and peptonisation commences within three days and is complete within a week. No coagulation is seen.

Blood-serum shows an abundant greyish-white growth. Liquefaction is extremely rapid, starting within twenty-four hours. The whole of the slope is liquefied in four weeks.

On blood-agar the medium changes in colour within twenty-four hours to a greenish tinge, and in forty-eight hours it becomes brown.

Starch is hydrolysed.

A creamy-white, glistening moist growth occurs on potato; the growth on alkaline potato is similar in colour, but is rather duller.

Acid is formed from glucose, sucrose, salicin, maltose, glycerin, laevulose, and dextrin.

The organism is a facultative anaerobe; its optimum temperature is about 37° C.

It is pathogenic to frogs, causing in them a haemorrhagic oedema; also to guinea-pigs, both on intraperitoneal and subcutaneous injection.

Organism " Q."

This is a Gram-negative coccus. It occurs singly, in pairs, and in irregular clumps. It varies in size from 1·0 to 1·2 microns in diameter. Some of the organisms tend to lose their coccoid forms and to become short bacilli; these, however, are very seldom seen, the majority retaining their circular outline.

Agar colonies of twenty-four hours' growth aerobically, at 37° C., are small, dew-drop, and discrete; they are brittle and hard to the needle. The edges are entire and the colonies circular, averaging about 0·1 mm. in diameter.

When sown on to anaerobic agar-agar McLeod plates a much better growth occurs, the colonies resembling those grown aerobically, but averaging 0·5 mm. in diameter. Growth at room temperature (18° to 20° C.) was much less active, the colonies being visible with the aid of a lens only at the end of twenty-four hours.

When grown anaerobically on dextrose-serum agar the growth is more profuse than on similar agar-agar plates.

Gelatin stabs show no liquefaction ; the growth is seen extending from 0·5 cm. below the surface of the medium along the entire depth of the stab.

On potato and on alkaline potato no growth is seen. Indol is not formed from peptone water, and nitrates are not reduced to nitrites. Litmus-milk is decolorised from 0·75 cm. below the surface, when it is inoculated and incubated aerobically. No gas is formed from the milk.

Dextrose is slightly fermented, and lactose is not affected.

Blood is not haemolysed, blood-serum is not liquefied, and broth remains clear.

The organism is not pathogenic to frogs or to guinea-pigs.

Organism "*S.*"

This is a non-motile, Gram-negative spirillum. It occurs singly, S-shaped forms consisting of a pair of bacilli being seen.

Agar colonies of twenty-four hours, grown at 37° C., are about 0·1 mm. in diameter, white in colour, and glistening. They resemble spots of greyish-white paint ; their edges are entire and sheer, and they are slimy to the needle. Colonies of four days' growth are 2 mm. in diameter, and show these characteristics in a more marked degree.

Gelatin colonies are similar to those grown on agar ; the medium is slowly liquefied round these. Gelatin stabs show growth on the surface and down the line of the stab ; liquefaction is slow and regular, it is crateriform in character.

Broth shows a flocculent deposit, a turbidity above this, and a heavy, thick, semi-transparent pellicle.

No indol is formed from peptone water ; the medium develops an even turbidity with a well-marked pellicle. A powdery sediment settles down to the bottom of the tube.

Acid only is formed from glucose, glycerin, maltose, laevulose, and sorbite.

Starch is not hydrolysed, milk is neither acidified nor coagulated, and nitrates are reduced very slowly, the reduction being apparent only after forty-eight hours.

Blood-serum is liquefied. Blood itself is not haemolysed.

The organism is a facultative anaerobe ; its optimum temperature is in the neighbourhood of 37° C.

Experimental.

A twenty-four-hour agar slope of " P," grown at 37° C., was injected intra-peritoneally into a rabbit but had no effect on the animal. 0·1 c.c. of a sterile saline emulsion of a similar slope was injected intracutaneously into another rabbit. Within six hours a reddening of the skin immediately round the site of the injection was observed, and a slight thickening was felt. After twenty-four hours the site was marked by a small, raised nodule. This was excised and sectioned for microscopic examination ; it presented the appearance of a small abscess, and showed polymorphic neutrophile and eosinophile infiltration, the eosinophils predominating.

An intracutaneous control injection of 0·1 c.c. of 0·85 per cent. sterile saline showed after twenty-four hours no visible or palpable reaction.

On injection of a twenty-four-hour slope emulsified in sterile saline intraperitoneally into a guinea-pig, the animal started twitching and scratching its nose two hours after the injection, and was dead an hour after the twitchings commenced. On autopsy, about 3 c.c. of clear serous fluid, which coagulated later, was found in the peritoneal cavity. The blood was tarry in appearance, and the peritoneum and the surface of the gut showed a marked degree of engorgement. The heart was slightly enlarged, the liver dark, and the spleen dark and slightly increased in size. The kidneys, suprarenals, and lungs appeared to be normal.

The organism was isolated in pure culture from the peritoneal fluid and from the spleen, but not from the heart and lungs.

Three-quarters, one-half, and one-quarter slopes, injected intraperitoneally, killed guinea-pigs in the same time.

Microscopically, the kidneys of these guinea-pigs were normal, and the liver, while showing many organisms in its substance among the columns of cells, still retained its normal cellular appearance.

The general picture is that of an exceedingly acute toxaemia, the invasive ability of the organism being at the same time quite marked.

Subcutaneous inoculation of a guinea-pig with one twenty-four-hour agar slope led to the formation of an abscess locally. The animal exhibited a marked polymorphic leucocytosis, as well as a certain degree of fever.

Intraperitoneal injections of frogs killed them within eighteen hours : even one-thirtieth of a slope grown at 37° C. was fatal in that time. The animals became lethargic and somewhat pale, and on several of them a pinkish discoloration of the flanks was seen. On opening the abdomen a blood-stained fluid escaped under pressure. This proved to be swarming

with the organisms which were present in pure culture. The abdominal viscera showed an acute degree of inflammation ; the heart was stopped with the ventricle somewhat contracted.

Frogs inoculated into the dorsal lymph sac died within twenty-four hours. No inflammation was seen at the site of inoculation, but the abdominal contents showed changes identical with those seen in the intraperitoneally injected animals. The organism was isolated in pure culture from the peritoneal fluid.

Frogs were injected with one-tenth slopes intramuscularly, the gastrocnemii and the pectoral muscles being chosen for this. These animals showed a haemorrhagic oedema at the site of inoculation, a general subcutaneous haemorrhagic exudate rich in the organisms, and a zone of inflammation extending from the site of injection. The viscera in these frogs were normal.

Scarification of the skin and rubbing the organisms on to the scarified area did not affect the animals, neither did feeding them with pure cultures.

As the results of animal inoculations resembled a toxic manifestation, an attempt was made to isolate the " toxin." The organisms were grown on broth for four days and the broth was then filtered through a Berkfeldt filter (No. V). Three c.c. of the sterile filtrate was injected intraperitoneally into a guinea-pig with no effect. The organisms were then sown on to agar plates ; these were incubated at 37° C. for twenty-four hours and the growth taken up in sterile saline, thoroughly shaken, and filtered : this filtrate was also non-toxic. This appeared to exclude the presence of a true soluble toxin. The organisms, grown on agar as before, were then taken up in saline and frozen and thawed alternately three times. This process did not destroy all the bacteria, and the resulting liquid was filtered. The filtrate, however, was innocuous. The residual organisms, proven by culture to be alive, were emulsified in saline, an equal quantity of ether was added, and the whole, after thorough shaking, was incubated at 37° C. overnight to remove the ether. It was hoped by this to dissolve the presumably lipoidal cell-membrane of the bacilli, and to allow the contents containing the "endotoxin" to be liberated. The fluid next day was sterile, but also non-toxic.

Boiled suspensions of fresh agar cultures were non-pathogenic.

" Q " and " S " were not pathogenic to frogs or to guinea-pigs whether inoculated intraperitoneally or by any other route.

Mixtures of " P " and " S," " Q " and " S," " P " and " Q," and " P," " Q," and " S " were inoculated intraperitoneally into frogs. The animals which had had " P " injected into them died in twenty-four hours ; the others were unaffected.

Classification.

The classification of the aerobic spore-bearing organisms appears to be attended with the greatest difficulties. Ford (1) classifies them by their pathogenicity, size, and size and shape of their spores. According to his classification, therefore, " P " falls into the pathogenic group which is composed of *B. anthracoides*, *B. aerobius sepis*, *B. piliformis*, and *B. anthracis*.

B. anthracoides is a Gram-positive spore-bearing aerobe, isolated originally from soil by Hueppe and Wood (2). Sheen and Klein (3) isolated a similar organism from gangrenous war wounds, as did Weinberg and Sèguin (4) ; Hiss and Zinsser (5) state that this organism is not pathogenic. It is stated by Ford to be practically identical with *B. cereus*, and strains labelled *B. anthracoides* and sent to him have always proved to be *B. cereus*.

Legros and Lecéne (6) describe a *B. aerobius sepis* isolated from a fatal case of gas gangrene. This is actively motile, Gram-positive, and produces a foetid odour on cultivation. Subcutaneous inoculation in guinea-pigs produces a fatal gas gangrene in adults and a septicemia in young animals.

Tyzzer (7) isolated a *B. piliformis* from Japanese waltzing mice. It is a long, slender, sporogenic Gram-negative bacillus exhibiting marked pleomorphism. Attempts at pure cultivation failed. The organism was pathogenic only to Japanese waltzing mice, and to them only by feeding on diseased livers or by inoculation by the intravenous route.

Hall (8) describes several types of spore-bearing " Hay bacilli " which proved pathogenic to guinea-pigs, usually producing a local abscess on subcutaneous injection. He isolated these from Malayan blow-gun poisoned darts, and makes no attempt at classifying them, stating that the comprehensive descriptions of Ford and his collaborators left him without accurate definitions of species, and that Bergey's key (9) attempted to utilise for major subdivisions characters which seemed to him variable and uncertain, such as length of chains, form of liquefaction in gelatin, and the presence or absence of pellucid dots on surface cultures.

Nevertheless, while recognising the force of some of Hall's statements, the authors feel that it is only by following the classifications of such compilers as Bergey and Ford that any sort of order may be made of a mass of data which is admittedly complicated enough.

Of the non-motile, sporing, facultative anaerobes, *B. anthracis*, which was first cultivated outside the body and fully described by Koch (10), forms acid from milk and coagulates it, does not reduce nitrates, and neither hydrolyses starch nor forms indol. Eurich (11) gives a minute description of colonies of this organism, with the special method he devised for isolating it from cases of suspected infection. We used his method for obtaining deep colonies, and compared them with the plates in his paper.

Bergey's classifications of these organisms is carried out by comparisons of their cultural reactions. According to him, therefore, " P " must be distinguished from *B. graveolens*, *B. panis*, and *B. adhaerens*.

B. graveolens, isolated by Gottheil (12) from soil, is non-pathogenic, and does not reduce nitrates, form indol, or liquefy blood-serum.

B. panis, isolated by Vogel (13) from dough, does not form indol or reduce nitrates, and does not hydrolyse starch. It is non-pathogenic.

B. adhaerens, isolated by Ford (14) from soil, does not form indol or reduce nitrates, and neither hydrolyses starch nor liquefies blood-serum. It is also non-pathogenic.

With regard to " Q," Bergey classifies it under the genus " micrococcus." Of the anaerobic species which form no pigment, *M. buccalis*, described by Ozaki (15), was isolated from the oral cavity. It forms gas from milk, grows on potato, and produces acid and gas from glucose and lactose. *M. gingivalis*, described by the same author (16), produces gas in milk, does not grow on potato, and was also isolated from the oral cavity.

Gioelli (17) describes a *Staphylococcus minimus*, which Bergey classifies as *Micrococcus minimus*. This measures 0·2 to 0·3 microns in diameter, occurs singly, and was isolated from a case of pelvic cellulitis. It grows neither on potato slopes nor on gelatin stabs.

The vibrios, into which genus " S " falls, are classified by Bergey by their pathogenicity, their power to coagulate milk, and their ability to form indol. *Vibrio strictus*, isolated by Kutscher (18) from water, is pathogenic to guinea-pigs and does not coagulate milk or form indol. It is motile, Gram-negative, and measures about 0·8 by 4·0 microns. *V. aquatilis*, described by Günther (19) and Migula (20), liquefies gelatin and is non-pathogenic, but is motile and Gram-negative. *V. tyrogenus*, isolated by Denecke (21) from cheese, is a motile curved rod, often appearing in long, closely wound spirals, and is Gram-negative. It liquefies gelatin stabs rapidly, and forms a yellowish-white, plumose, glistening growth on agar.

Discussion.

Whilst " Q " and " S " are ineffective on frogs, " P " is especially virulent to these animals. We are inclined to regard " Q " and " S " as contaminants, whereas " P " is in all likelihood the causal organism of the abscess. The reason why abscesses were not produced is probably that the doses of organisms used were too large, or that the organisms were not reduced in virulence sufficiently. It was found, however, that even after growing on agar for three months, both at 37° C. and at 20° C., the organisms retained their full virulence.

In a previous paper one of us (Th. Schrire) (22) collected the names of

	Organism "P."	Organism "Q."	Organism "S."
Gram	+	—	—
Motility	—	—	—
Glucose	A	A	A
Lactose	—	—	—
Maltose	A	?	A
Mannite	—	A	—
Dulcite	—	—	—
Saccharose	A	—	—
Galactose	—	—	—
Laevulose	A	A	A
Rhamnose	—	—	—
Adonite	—	—	—
Inulin	—	—	—
Sorbite	—	A	A
Dextrin	A	—	—
Salicin	A	A	—
Raffinose	—	—	—
Inosite	—	—	—
Xylose	—	—	—
Arabinose	—	—	—
Glycerin	A	—	A
Blood-serum	Liquefied.	Not liquefied.	Liquefied.
Haemolysis	—	—	—
Starch hydrolysis	+	—	—
Indol formation	+	—	—
Nitrates	Reduced.	Not reduced.	Reduced slowly.
Milk	Peptonised.	—	—
Gelatin liquefaction	+	—	+
Optimum temperature	37° C. Aerobic.	37° C. Micro-aerophilic.	37° C. Aerobic.

(A = acid formed.)

NOTE.—No gas was formed from any carbohydrate—sugar or glucoside.

some of the commoner organisms which have been found to be pathogenic to frogs. In addition, Ford mentions a *Bacillus ranicida* described by Ernst (23). This is a small Gram-negative bacillus, which, when injected into the dorsal lymph sacs of frogs, brings about the death of the animals in two to five days, the organism being isolated from the heart and organs. The animals were more susceptible when kept artificially at low temperatures than at high temperatures. The organism itself grows best at 20° to 30° C., no growth occurring at 8° C. or at 38° C.

Ford mentions likewise the *B. septicaemia ranarum* described by Vénulet and Padlewski (24). This is a small, motile, Gram-negative

organism which is pathogenic to frogs, killing them in two to three days. The lymph sinuses and abdominal cavity are filled with turbid, opalescent, haemorrhagic fluid, the muscles are oedematous and haemorrhagic, and the spleen and liver are enlarged. The same organism is virulent to guinea-pigs on subcutaneous inoculation, and bacteria-free filtrates of seven-day cultures are also pathogenic to guinea-pigs and white mice.

" P " has proved to be pathogenic to frogs even in such small intraperitoneal doses as one-thirtieth of a twenty-four-hour agar slope. This immediately distinguishes it from *Bacillus anthracis*, which Kolle and Wasserman (25), on Dieudonne's (26) authority, state to be pathogenic to amphibia only when the latter are kept at a temperature of 35° C., or when anthrax organisms are accustomed, by many transplantations (during which the power to sporulate is lost), to grow at 15° C. can frogs be infected and killed when they are kept at room temperature.

The temperature of the tap-water while our experiments were being carried out varied from 12° to 18° C., and the frogs exist at water temperature. Although " P " was cultivated and subcultured at 37° C. all the time, it lost none of its virulence to these animals.

We suggest that " P " be named *Bacillus fulminans*, " Q " *Micrococcus xenopus*, and " S " *Vibrio xenopus*.

Summary.

1. Three new organisms, isolated from an abscess accidentally discovered in a frog (*Xenopus laevis*), have been described and named.

2. One of these organisms is pathogenic to frogs, guinea-pigs, and rabbits. This organism has been named *Bacillus fulminans*.

3. The other two organisms are non-pathogenic. These have been named *Micrococcus xenopus* and *Vibrio xenopus* respectively.

4. The abscess could not be reproduced.

The authors wish to express their thanks to Professor W. Campbell, of this University, for his helpful interest and advice in this work.

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THE SPECIES OF *ISOETES* FOUND IN THE UNION OF SOUTH AFRICA.

By A. V. Duthie.

(From the Botanical Department, University of Stellenbosch.)

(With Plates XI and XII and seven Text-figures.)

Of the sixty-four species of *Isoetes* recognised by Pfeiffer * in a recently published monograph of the genus four are recorded from Algeria, one from the Anglo-Egyptian Soudan, one from Nigeria, two from Angola, and two from the Cape.

The first species of *Isoetes* to be described from what is now the Union of South Africa was a plant collected by Rehmann at Griffin's Hill, Eastcourt, Natal, between 1875 and 1880, and named by Baker † *Isoetes natalensis*. Specimens of Rehmann's plant are preserved in the Kew Herbarium. Of recent years Dr. T. R. Sim ‡ collected what he considered to be the same species at Upper Mooi River, near the Berg, and figured it in his Ferns of South Africa. Unfortunately, it has not been possible to trace this specimen. Marloth, § in vol. i of his Flora of South Africa, published in 1913 a figure of the entire plant of *I. natalensis*, together with the microspore and base of a fertile leaf. All three figures are stated to have been drawn from nature—probably from type material in the Berlin Herbarium. In addition to the above, incomplete specimens of a plant collected by Lehman, presumably in the Cape of Good Hope, are preserved in the Gray Herbarium, Harvard, and in the Herbarium of the Missouri Botanical Garden. These specimens were examined by Pfeiffer * and assigned to *I. natalensis*.

In December 1893 Mr. W. H. Wormald found a species of *Isoetes* growing submerged in pools near East London. This species was named *I. Wormaldii* by Sim,‡ after the finder, and described and figured in 1906 in the Trans. S.A. Phil. Soc. and, later, in the Ferns of South Africa. Specimens of *I. Wormaldii* may be seen in most of the South African herbaria.

* Pfeiffer, 1922.
† Baker, 1887.
‡ Sim, 1915, 1906.
§ Marloth, 1913.

Until 1921 no representative of the genus was known from the south-western part of the Cape Province, but in this year Miss E. Stephens of the Cape Town University found *Isoetes* growing in abundance in several shallow, temporary vleis in the Cape Peninsula. Material submitted to Dr. Sim was assigned by him provisionally to *I. natalensis*. This plant has been found to differ in several important respects from the type specimen of *I. natalensis* at Kew, and has therefore been raised by the writer to specific rank, and is described in this paper under the name *Isoetes capensis*.

In October 1927 Miss A. J. Stephansen of the Stellenbosch University collected a species of *Isoetes* in marshy ground on the Stellenbosch Flats, which was found on examination to resemble the Peninsula plant very closely. Further search by the writer resulted in the discovery on the Stellenbosch Flats of two additional species. A brief account of one of them, under the name *Isoetes stellenbossiensis*, appeared in the Minutes of Proceedings, Roy. Soc. of S.A., for 1928; the other has been named *Isoetes Stephansenii* after the collector of the first Stellenbosch species of the genus.

There is little doubt that further search for *Isoetes* will show that the species are less restricted in distribution than would appear from our present knowledge. It must not be forgotten that the terrestrial and amphibious forms are often found growing among sedges, grasses, etc., which they resemble so closely that they may be overlooked even by careful collectors.

The writer is indebted to the Director of the Royal Botanical Gardens, Kew, for the loan of part of Baker's type of *I. natalensis*, to the Gray Herbarium for the loan of Lehman's specimen, and to the Albany Museum, Grahamstown, and the National Herbarium, Pretoria, for dried specimens of *I. Wormaldii*. The material of the latter species in the Bolus Herbarium and in the South African Museum Herbarium has also been examined. It is a pleasure to acknowledge the kindness of Miss E. Stephens, who has not only supplied a large amount of fresh material of the Peninsula plant, but has also made it possible for the writer to study this species in its natural habitat. Thanks are also due to Professor Bews and to Dr. G. Rattray for living material of *I. Wormaldii*, to Mr. H. Herre for the photograph reproduced in Pl. XI, fig. 1, to the Botanical Department, University of Cape Town, for the photographs of megaspores, and to Dr. T. R. Sim for much useful information.

Pfeiffer * has pointed out that the old subdivision of the genus *Isoetes*, according to habitat alone, is unsatisfactory. Although the majority of South African species occur in areas which dry out completely for a part of each year, observation and experiment show that several are able to adjust themselves in a marked degree to altered conditions of the habitat.

* Pfeiffer, 1922.

Specimens of *I. capensis* submerged by Miss E. Stephens in 1925 and kept under water since then have remained green for over three years, although normally this species disappears completely, except for the corms, during the dry season. It is interesting to note that prolonged immersion has not produced any marked elongation of the leaves nor any change in their form. On the other hand, Sim found that *I. Wormaldii*, when grown in deep water, may produce leaves up to 45 cm. long, though the same species assumes a stunted form when growing in damp mud. According to Guppy,* *I. lacustris*, var. *azorica* responds to changed conditions in much the same way as *I. Wormaldii*, exhibiting a dwarf form on exposed mud flats and a large form with long, cylindrical leaves in deep water. *I. Stephansenii* and *I. stellenbossiensis* are being grown under different environmental conditions, but some time must elapse before conclusive results are obtained.

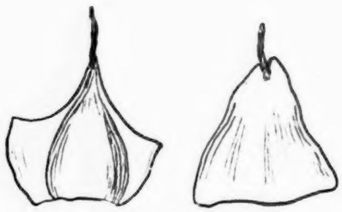
Pfeiffer † divides the genus into four main sections—Tuberculatae, Echinatae, Cristatae, and Reticulatae—based on the sculpturing of the megaspores. This classification has not been adopted, as two of the south-western species—*I. Stephansenii* and *I. capensis*—exhibit so much variation in spore-marking that they cannot be fitted into any one of Pfeiffer's sections. The size of the plants, the number of leaves produced, and the dimensions of the sporangia have been found to vary greatly with the age of the specimen examined, and consequently to be of little use as diagnostic features.

In distinguishing the species a combination of the following characters has been found to be of systematic value : colour, size, and markings of the megaspores and microspores ; presence or absence of a velum ; character of corm-scales ; lobing of the corm ; leaf-form and leaf-anatomy. The mature megaspores are white or grey in most of the species examined, but in *I. stellenbossiensis* they have a distinctly greenish tinge and darken considerably on moistening. The markings of the megaspores are very constant in the two reticulate species, *I. Wormaldii* and *I. stellenbossiensis* (Pl. XII, fig. 4 ; Pl. XI, fig. 2). In *I. capensis* and *I. Stephansenii*, on the other hand, the sculpturing of the spore surface may vary from scattered tubercles to irregular anastomosing ridges or a perfect reticulum in specimens of the same gathering (Pl. XI, fig. 3; Pl. XII, figs. 1, 2). Variations have also been observed in the spores of a single sporangium or on the faces of a single spore. It is not unusual for a few small spores to occur among those of normal size, especially in the first-formed megasporangia (Pl. XII, fig. 3). These were discarded in taking the dimensions of the megaspores in the different species. In *I. capensis* ‡ and *I. Stephansenii* the velum is com-

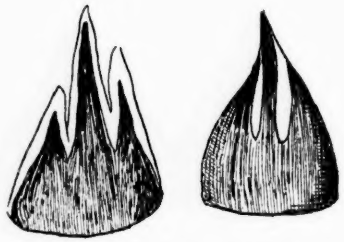
* Guppy, 1914. † Pfeiffer, 1922.

‡ A single abnormal microsporangium with an incomplete velum was found in this species.

plete, but it is absent in the remaining three South African species. Pfeiffer * reports that Lehman's specimen in the Herbarium of the Missouri Botanical Garden, assigned by her to *I. natalensis*, has a very narrow velum; but there



TEXT-FIG. 1.—*I. capensis.* Bud scales.



TEXT-FIG. 2.—*I. stellenbossiensis.* Bud scales.

seems no certainty that this plant was actually collected in South Africa. The three south-western species have the growing apex of the corm protected during the resting season by a series of dark-brown, overlapping scales, which represent morphologically the bases of undeveloped foliage leaves. Transitions between them and sterile green leaves are met with. In *I. capensis* and *I. Stephansenii* the scales persist as somewhat leathery structures surrounding the new cluster of sporophylls, and may also be found surmounting the caps of dead cortical tissue which functioned during previous years (text-fig. 1). These scale-leaves are identical with those described by Osborn † for *I. Drummondii* and doubtless, also, with the "tiny basal scales" referred to by Pfeiffer * in a footnote to *I. mexicana*. In *I. stellenbossiensis* the bases of the protective scales formed at the end of a season's growth resemble those of *I. hystrix* and *I. Duriaei*—both of which are recorded from Algeria—in possessing three horny, prong-like teeth, while the bases of the sporophylls persist as imbricating scales which are destitute of teeth (text-figs. 2, 3). It is possible that *I. natalensis* may prove to have well-developed, persisting bud-scales. Unfortunately the type specimen at Kew seems to be somewhat imperfect

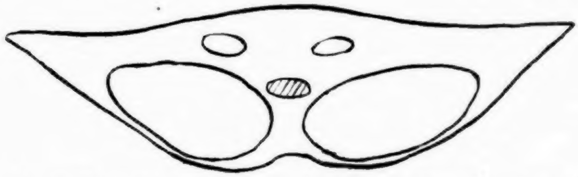
TEXT-FIG. 3.—*I. stellenbossiensis.* Corm with bud scales and persistent bases of sporophylls.

* Pfeiffer, 1922. † Osborn, 1922.

at the base and does not throw any light on this point, nor do either of the published figures.

The lobing of the corm has always been regarded as of great systematic value. Pfeiffer * states: "The number of lobes . . . is characteristic of the species concerned, save in the rare cases where three lobes may be found in a usually bilobed form or four in a trilobed." Of the five South African species described in the present paper only one—*I. Stephansenii*—appears to be consistently 2-lobed. Although large numbers of plants of *I. stellenbossiensis* and *I. capensis* have been examined, only a single specimen belonging to the former species and three belonging to the latter were found to possess 4-lobed corms. Three plants of the latter species showed a 2-lobed corm, but in one of them the failure of the third lobe to develop was obviously the result of injury. The remaining abnormal specimens have been fixed with a view to further study. In *I. stellenbossiensis* the caps of old cortex which persist for several seasons are not easily detached even after prolonged soaking. In *I. capensis* the caps may be removed with a little pressure, while in *I. Stephansenii* the old cortical caps usually separate so readily from the living tissue that care is needed in removing the plants from the soil and in washing them if the dead tissues are to be kept in position.

The leaf characters were found to vary greatly in the different species. In *I. Wormaldii* the flattened leaves, which are usually completely sub-

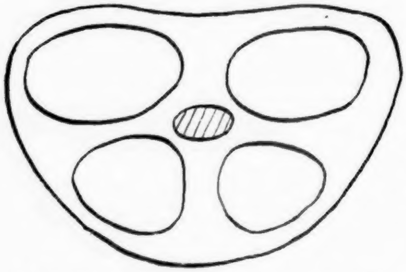


TEXT-FIG. 4.—*I. Wormaldii.* Transverse section of lamina about 6 cm. from leaf apex.

merged during the growing period, narrow somewhat abruptly at the blunt apex. The abaxial air-canals are well developed and roofed over by a single layer of cells; the adaxial canals are poorly developed in the lower part of the leaf, and disappear completely towards the flattened, paddle-like tip (text-fig. 4). Numerous stomata are present on the adaxial surface of the upper part of the leaf. Strengthening fibres are entirely absent. The solid tissue near the leaf margins gives a false impression of lateral veining. In *I. capensis* and *I. Stephansenii* all four air-canals are well developed, and are roofed over by a double cell-layer which is perforated by stomata (text-fig. 5). Strengthening fibres are wanting. The type

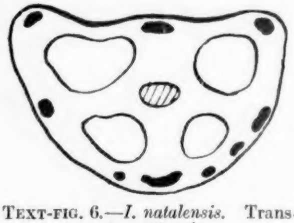
* Pfeiffer, 1922.

specimen of *I. natalensis* shows very narrow leaves which are rounded on the back and flat or furrowed above, and are provided with stomata and strengthening fibres (text-fig. 6). The groups of fibres were found to vary from four to nine in a single leaf. Lehman's specimen in the Gray Herbarium has leaves which, except for their greater length, resemble those of the type very closely. The narrow leaf of *I. stellenbossiensis* is the most xerophytic of all the South African species (text-fig. 7). It is rounded below and flat above; the air-canals are very poorly developed, the adaxial being smaller than the abaxial and disappearing completely about 2 cm. from the awl-shaped leaf apex. Stomata are present, and there are three well-developed groups of strengthening tissue, one at each side of the adaxial face and one at the abaxial end of the middle partition.

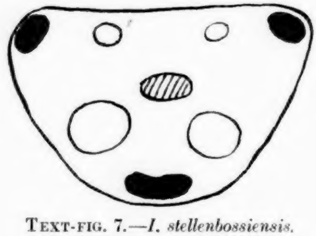


TEXT-FIG. 5.—*I. capensis.* Transverse section of lamina a little above ground level.

The present paper is concerned with the systematic treatment of the genus, only such anatomical matter being included as has been found to be of value in discriminating the species. An account of the comparative anatomy of the South African forms, together with notes on their life-histories and their methods of spore dispersal, will be published later. Specimens from other parts of the country will be very welcome, and the writer will gladly refund any expense incurred in forwarding material.



TEXT-FIG. 6.—*I. natalensis.* Transverse section of lamina.



TEXT-FIG. 7.—*I. stellenbossiensis.* Transverse section of lamina.

Key to Species.

I. Velum none or little developed.
  Megaspores tuberculate . . . . 1. *I. natalensis.*
  Megaspores reticulate.
    Leaves slender, strengthening fibres present . . 2. *I. stellenbossiensis.*
    Leaves more or less flattened, strengthening fibres absent . . 3. *I. Wormaldii.*
II. Velum complete.
  Corm 2-lobed . . . . 4. *I. Stephansenii.*
  Corm 3-lobed . . . . 5. *I. capensis.*

1. **I. natalensis,** Baker, Handbook of Fern Allies, 132, 1887; Marloth, Flora of South Africa, vol. i, fig. 61, 1913; Sim, Ferns of South Africa, 340, pl. 184, 1915.

Corm 3-lobed; leaves 10–20, very slender, with awl-shaped apex, pale green, opaque, firm in texture, 3–7·5 cm. long, about 0·5 mm. diam., rounded on the back, somewhat channelled down the face, furnished with stomata and strengthening fibres; sporangia small, globose; velum absent; megaspores white, with fairly large, scattered tubercles on the basal face and smaller ones over the apical faces; microspores granulated.

Griffin's Hill, Eastcourt, Natal (Rehmann, 7296); Upper Mooi River, near the Berg (T. R. Sim).

The only authentic material of this species examined by the writer was a part of the type belonging to the Kew Herbarium. Transverse sections of the leaf showed four air-canals separated by partitions 7–8 cells wide. The groups of strengthening fibres varied from 4–12 in the leaves cut, and were very unequal in size and shape, smaller ones separating from the larger at intervals. The megasporangia examined were somewhat flattened above, with a very narrow marginal rim. A number of under-sized spores were found among the larger ones. The latter were from 350–480 μ diam. The markings on the outer spore face consisted of spherical tubercles; on the apical faces the tubercles were, for the most part, considerably smaller (Pl. XII, fig. 3). No microspores were seen.

Lehman's specimens, referred to in the introduction, possibly belong to *I. natalensis*. The sheet from the Gray Herbarium has the following pencil note in Dr. Gray's writing: "Engelm. doubts if it comes from C.B.S. No sp. known from there." The specimens have 10–11 slender leaves, up to 35 cm. long and from 0·5–1 mm. wide, the lower 3–4 cm. narrowly winged along the margins. Sections cut through the lamina showed all four canals fairly well developed, separated by partitions 6–9 cells wide and with 7–9 groups of strengthening fibres. The oblong sporangia in the Gray Herbarium specimen are destitute of a velum, but Pfeiffer * reports the presence of a very narrow velum in the Mo. Bot. Gard. Herb.

* Pfeiffer, 1922.

specimen. The whitish megaspores are from 465–600 μ diam., with small prominences and short ridges on the curved face. The microspores are light brown in colour, 30–36 μ long, minutely spinulose or almost smooth on the outer face. It is possible that both mega- and microspores are immature.

Judging from the leaf anatomy it seems probable that *I. natalensis* is a terrestrial species, and this may account for its infrequent collection. The type specimen examined, however, shows no indication of bud-scales at the base of the corm, nor do either of the drawings referred to above. It is greatly to be hoped that collectors in Natal will make a careful search for this interesting species, so that living material may be available for study.

2. **I. stellenbossiensis.** sp. nov.

Cormus trilobatus, asper, ad 1·5 cm. diam., partibus inferioribus foliorum delapsorum vestitus, ex squamis nonnullae tricuspides ; folia numero 5–33, ad 12 cm. longa, 0·5–1 mm. lata, acuta, stomatibus et fibris periphericis tribus instructa ; vagina folii membranacea, dilatata, parte inferiore persistente ; lingula parvula, elongato-triangularis ; sporangia orbiculata vel oblongata, sine velo ; megasporae globosae, subvirides, diam. 450–590 μ, reticulatae ; microsporae fuscae, longitudine 32–36 μ, spinulosae.

Corms 3-lobed, harsh to the touch, up to 1·5 cm. diam. ; sclersised bases of sporophylls and bud-scales persisting, the latter horny and three-toothed ; leaves 5–33, 1·5 to 12 cm. long, firm in texture, sheathing base 1 cm. or less wide, often narrowing somewhat abruptly above the level of the sporangium ; lamina 0·5–1 mm. wide, rounded on the back, flat or slightly furrowed above, furnished with stomata ; three well-developed groups of strengthening fibres present, one at each angle of adaxial face and one at abaxial end of middle partition ; air-canals poorly developed, the adaxial disappearing near the leaf apex ; ligule small, delicate in texture, elongate-triangular, sometimes cordate at base, in old leaves often imperfect through decay ; velum absent ; sporangia varying much in size and shape, the older megasporangia often circular in outline, the younger oval or elliptical ; microsporangia conspicuously punctate, innermost often angled by pressure ; both mega- and microsporangia rounded on the back and with adaxial face flat or slightly concave, and usually bordered by a narrow rim ; some of the cells of the sporangial wall conspicuously thickened, often yellowish-brown in colour ; megaspores globose, from 450–590 μ in diam., basal face conspicuously reticulate, reticulations often less regular along the equatorial ridge and on the apical faces ; colour of adult megaspores greenish-grey,* darkening appreciably on

* Tea green, darkening to Andover green or dark Andover green on moistening. (Ridgway's colour standard.)

moistening; microspores 32–36 μ long, 16–24 μ broad, brown * in colour, spinulose.

This is the most abundant species of Isoetes met with on the Stellenbosch Flats. It occurs in ground which is marshy during the rainy season, often extends to drier areas and is then truly terrestrial. In favourable situations it grows so compactly that it may easily be mistaken for a narrow-leaved grass. The corms are very rarely found near the surface of the soil with the bases of the outer sporophylls exposed and green in colour; as a rule they are deeply buried in the earth—sometimes to a depth of 6 cm. Among the associated plants the following may be mentioned: Shrubs—*Psoralea pinnata*; grasses and sedges—*Pennisetum macrourum, Sporobolus indicus, Cynodon dactylon, Pentaschistis* sp.; geophytes—*Hypoxis aquatica, Wurmbea capensis, Haemanthus Pumilio, Micranthus* sp., *Triglochin bulbosum, Anthericum* spp., *Oenanthe filiformis, Eriospermum cernuum, Romulea* spp., *Ornithogalum thyrsoides, Disa tenella, Drosera* spp., *Oxalis* spp., *Isoetes capensis, I. Stephansenii*; annuals—*Sebaea albens, S. pusilla, Pharnaceum pusillum, Felicia tenella, Utricularia capensis, Monopsis debilis, Melasma sessiliflorum, Heliophila pusilla, Selaginella pumila.* It has occasionally been found growing beside pronounced xerophytes such as *Crassula undulata, Aristea cyanea,* and *Relhania ericoides.*

This species is readily recognised by the 3-toothed bud-scales, narrow, opaque leaves with three conspicuous groups of strengthening fibres, poorly developed air-canals and greenish, reticulate spores (Pl. XI, figs. 1, 2, text-figs. 3, 7). The layers of old cortex persist for several seasons, and the series of horny, 3-toothed bud-scales mark the limits of the growth of successive years (text-fig. 3).

3. **I. Wormaldii,** Sim, Trans. S. Afr. Phil. Soc., vol. xvi, part 3, p. 299, pl. v, 1906; and Ferns of S. Afr., p. 340, pl. 185, 1915.

Corm 3-lobed; leaves 5–70 in number, somewhat flattened, 9–45 cm. long, 2–3 mm. broad, hardly narrowed to the rounded point, flaccid; stomata present on upper part of lamina, peripheral strands absent; ligule very delicate in texture, somewhat elongated; sporangia 2·5–10 mm. long, 2–5 mm. wide, lacking a velum; megaspores white, 400–640 μ diam., reticulated on all faces; microspores 24–35 μ long, 20–24 μ broad, minutely tuberculate.

Pools near East London, submerged or rooted in mud near margin.

This remarkable plant differs from all the other South African species of Isoetes in the greater breadth and more rounded apex of the lamina, as well as in the leaf anatomy and sculpturing of the megaspores (text-fig.

* Rood's brown, darkening to Vandyke brown on moistening. (Ridgway's colour standard.)

4; Pl. XII, fig. 4). All the leaves examined are conspicuously flattened. Stomata occur towards the ends of the laminae, and are confined to the upper surface. The abaxial air-canals are large and are roofed over by the epidermis only. As a rule the adaxial canals disappear entirely some centimetres from the leaf apex. Strengthening strands are wanting. The alternation of more solid and less solid tissue gives a false impression of longitudinal veining.

4. **I. Stephansenii,** sp. nov.

Cormus bilobatus, ad 11 mm. diam.; folia numero 5–15, 4–13 cm. longa, angusta, circa 1·5 mm. lata, versus apicem attenuata, versus basim membranacea, dilatata, stomatibus instructa, fibris, periphericis destituta; lingula parvula, cordato-triangulata; sporangia 3–5 mm. longa, et 2–3·5 mm. lata, velo completo; megasporae albae vel cineraceae, diam. 450–615 μ, tuberculis prominentibus vel brevibus vel extentis jugis ornatae, vel subreticulatae; microsporae fulvae, longitudine 28–36 μ, latitudine, 20–28 μ, raris longisque spinis tectae.

Corms 2-lobed, up to 11 mm. diam.; bud-scales trianguiar, leathery, dark brown; leaves 5–15 in number, up to 13 cm. long, slender, widening below into the sheathing base; membranous wing narrow, disappearing about 4 cm. above the sporangium; lamina about 1·5 mm. wide at soil level, tapering gradually to apex; stomata present; strengthening fibres absent; ligule small, cordate-triangular; sporangia 2·5–5 mm. long and 2–3·5 mm. broad; velum complete; megaspores white or grey, darkening somewhat on moistening, 450–615 μ diam., markings very variable, consisting of isolated knobs, or short ridges which may coalesce to form an incomplete reticulum; microspores yellowish-brown, 28–36 μ long, 20–28 μ broad, spinous, spines not closely crowded, about 3 μ long.

Seasonal swamp, Stellenbosch Flats, abundant; August to December.

The megaspores (Pl. XII, fig. 2) show much the same variations as do those of *I. capensis*, but the corm is 2-lobed and the microspores, in the material examined, have longer and more scattered spines. The dead cortex of the corm separates very readily from the living tissue. This species has been found growing with *I. stellenbossiensis*, but it usually occupies damper areas where the ground remains water-logged for a time after heavy rain. In addition to numerous grasses and sedges the following plant associates may be mentioned: *Psoralea pinnata*, *Eriospermum cernuum*, *Oenanthe filiformis*, *Triglochin* sp., *Anthericum scabrum*, *Melasma sessiliflorum*, *Monopsis debilis*, *Felicia tenella*, *Bryum aulacomnioides*.

5. **I. capensis,** sp. nov.

Cormus trilobatus; folia numero 5–35, 3–19 cm. longa, angusta, 1·5–2·5 mm. diam., versus apicem attenuata, versus basim dilatata marginibus hyalinis, stomatibus instructa, fibris periphericis destituta; lingula cordato-triangulata, membranacea, saepe ad apicem marcescens; sporangia longitudine 3–7·6 mm.,

latitudine 3–4 mm., orbiculata vel oblongata, velo completo ; megasporae albae vel cineraceae 390–570 μ diam., tuberculis prominentibus vel brevibus vel extentis jugis ornatae, vel reticulatae, raro glabrae ; microsporae fuscae, longitudine 24–36 μ, latitudine 20–30 μ, brevibus densisque spinis tectae.

Corm 3-lobed ; bud-scales triangular, leathery, dark brown ; leaves 5–35 in number, 3–19 cm. long, dilated at base, with membranaceous margins disappearing about soil level, middle part of lamina rounded below, flat above, the upper quadrangular in section, tapering gradually to an awl-shaped apex ; breadth at soil level 1·5–2·5 mm. ; stomata present, peripheral strands absent ; ligule cordate-triangular, delicate in texture, the upper part often much decayed ; sporangia 3–7·5 mm. long, 3–4 mm. wide, completely covered by the velum ; mature megaspores chalky white or grey, darkening on moistening, 390–570 μ diam., sculpturing very variable, surface sometimes smooth and marbled, usually rough with scattered tubercles, or with tubercles connected by short ridges or forming irregularly branching, vermiform ridges or an incomplete or complete reticulum ; markings on apical faces usually less perfectly developed than on basal face; microspores brown, 24–36 μ long, 20–30 μ wide, spinulose, spines short, densely crowded.

Temporary vleis in Cape Peninsula, abundant ; marshy ground on Stellenbosch Flats, occasional and very local ; August to December.

This species exhibits great variability in the sculpturing of the megaspores (Pl. XI, fig. 3 ; Pl..XII, fig. 1). The spores of the Peninsula plant often show reticulations on the rounded face—a condition which is only occasionally seen in the Stellenbosch plant. Here the megaspores are usually rougher, with marked tubercles or an imperfect reticulum with prominent warts at the nodes of the network. Large numbers of plants from both localities were examined and found to agree in the lobing of the corm, the characters of the leaves and the presence of a complete velum.

In the Peninsula vleis the plants are usually submerged during the rainy season, sometimes to a depth of 6 inches or more, though around the margins they may be completely exposed. Among the associated angiospermous plants may be mentioned *Ranunculus aquatica*, *Aponogeton angustifolium*, *Limosella* sp., *Anthericum longipedunculatum*, *Plantago carnosa*, *Salicornia* sp., *Crassula* sp., and *Triglochin* sp., while *Nitella*, *Spirogyra*, and *Zygnema* occur in abundance, and *Coleochaete* discs are often found on the submerged leaves.

Up to the present *I. capensis* has only been found in one locality on the Stellenbosch Flats, where it occurs in marshy ground intermixed with *I. stellenbossiensis* ; but it never spreads, as the latter species does, to dryer areas. Many of the associated plants are identical with those mentioned for *I. stellenbossiensis*.

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DESCRIPTION OF PLATES.

PLATE XI.

Fig. 1. *I. stellenbossiensis* to left, *I. capensis* to right of figure.
Fig. 2. *I. stellenbossiensis*, megaspores. × c. 25.
Fig. 3. *I. capensis* (from Stellenbosch Flats), megaspores. × c. 25.

PLATE XII.

Fig. 1. *I. capensis* (from Cape Peninsula), megaspores. × c. 25.
Fig. 2. *I. Stephansenii*, megaspores. × c. 25.
Fig. 3. *I. natalensis*, megaspores. × c. 25.
Fig. 4. *I. Wormaldii*, megaspores. × c. 25.

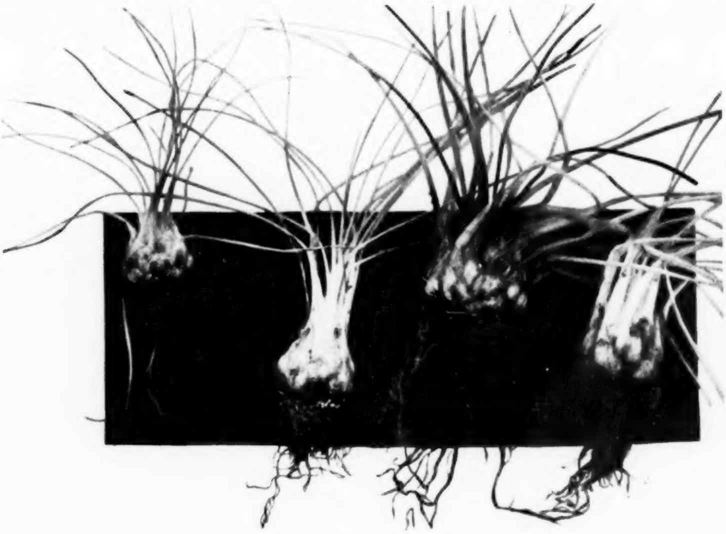

Fig. 1.

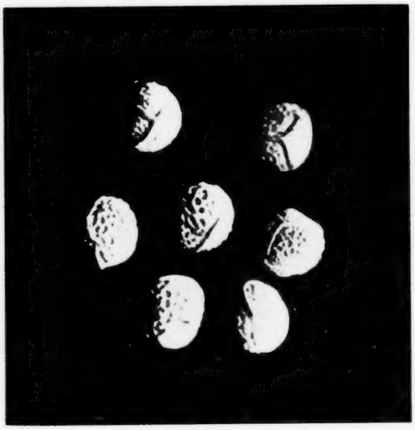

Fig. 2.

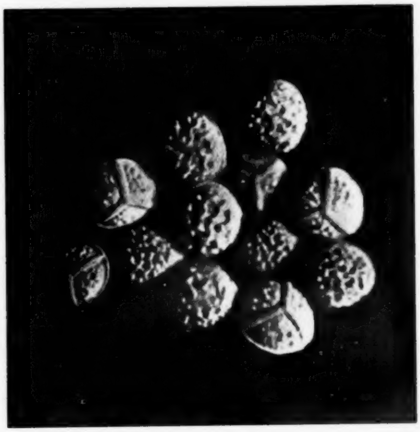

Fig. 3.

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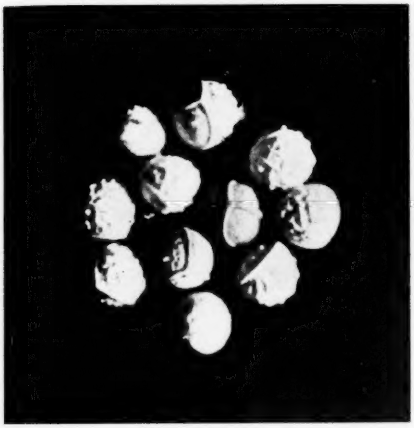

FIG. 1.

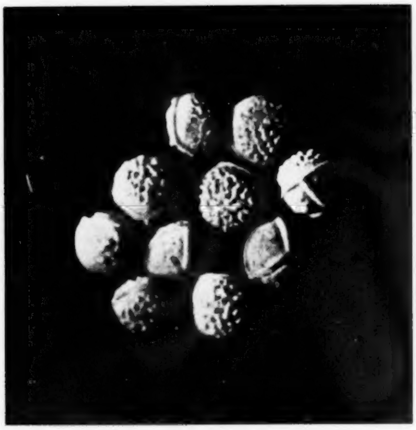

FIG. 2.

FIG. 3.

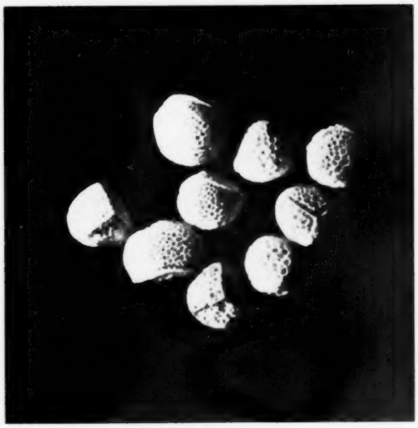

FIG. 4.

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SOME ACCOUNT OF A PEBBLE INDUSTRY IN THE TRANSVAAL.

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(Communicated by M. R. Drennan.)

(With Plates XIII–XXI.)

1. Introduction.

The purpose of this paper is to call attention to, and set forth evidence in support of, the existence in the Transvaal of a very primitive Stone Age culture which appears to have received little or no attention from pre-historians hitherto, but which is none the less widely distributed.

In August 1922 the artifacts herein described were collected at Belfast (Transvaal) by the writer, who had found implements of the same type in Ceylon as long ago as 1912,* and in Uganda and in Kenya in 1919.† It may be noted, too, as a matter of more than passing interest, that tools belonging to a very strikingly similar if not identical culture have been described from Suffolk (England).‡

2. Geographical Situation.

Belfast is, or was at the time of the writer's visit, a town with a population of between seven and eight thousand souls. It is situated on the high veld at an altitude of about 6500 feet above mean sea-level, and at a point about 136 miles from Pretoria on the direct railway route to Lourenço Marques. The writer discovered two Stone Age sites at Belfast; these are to be found between the railway and the hotel, which is (or was) situated on the outskirts (south side) of the town, about a mile north of the station.

* Wayland, E. J., "Outlines of the Stone Ages of Ceylon," Spolia Zeylanica, vol. xi, pt. 41, Oct. 1919, pp. 85–125.

† Wayland, E. J., "Palaeolithic Types of Implements in Relation to the Pleistocene Deposits of Uganda," Proc. Prehist. Soc. E. Anglia, vol. iv, pt. 1, 1923, pp. 96–112, as amended by Man, Art. 124, 1924.

‡ Reid-Moir, J., "A Series of Pre-Palaeolithic Implements from Darmsden, Suffolk," Proc. Prehist. Soc. E. Anglia, vol. ii, pt. 2, 1916.

3. General Geology.

Although the presence of coal-bearing Permo-carboniferous beds has occasioned a small amount of mining in the Belfast district, the prevailing rocks in the vicinity of the township are quartzites of the Pretoria series penetrated by dolerite intrusions, presumably of Karroo age. The latter have weathered to patchy residuals of red earth, some of which are 20 feet or more in thickness, and all of which in their constitution and cellular ironstone cappings resemble, very closely indeed, the so-called lateritic deposits of the tropics. So close is the resemblance between the Belfast residuals (and others in the Transvaal) and those which the writer has examined in Ceylon, India, Portuguese East Africa (north of the Zambesi), Kenya Colony, and Uganda, that he sees no alternative to the hypothesis that they are all of similar origin; and since it would appear that such occurrences are characteristically confined to the tropical zone, wherein they have resulted from chemical changes consequent upon the seasonal rise and fall of ground waters in areas of peneplaination, it is suggested that their presence in the Transvaal throws light on the past topographic and geologic conditions of that area.*

4. Stone Age Sites.

There are at least two Stone Age sites at Belfast; these the writer proposes to refer to as (A) and (B). The first yields artifacts of the peculiarly primitive culture with which it is proposed especially to deal; the second yields tools of Le Moustier facies, as developed in Central Africa—the *Sangoan* culture.

Site (*A*).—This lies to the east of the road which runs from the railway station to the town, and is situated on and around a small dolerite kopje about a quarter of a mile to the south (approx.) of the hotel. The kopje is strewn with quartzite pebbles that have, doubtless, been brought there by human agency. Cores and flakes of massive quartzite are markedly absent from this site, but a high percentage of the pebbles have been split, sliced, pointed, or edged in an unmistakably artificial manner. There are, too, hammer-stones—the usual end-battered pebbles common on Stone Age sites of all cultures and periods. The fractured surfaces of the various pebbles are all weathered to a similarly high degree. It would thus appear that the tools are contemporaneous productions and belong to antiquity. In consideration of the fact that they are all made from rounded stones, and for the want of a better name, the writer proposes for the purpose

* In a similar connection, see Presidential Address, Roy. Soc. N.S.W. (Australia), May 4, 1927.

of this paper to refer to these artifacts as pebble-tools. They belong, however, to a definite culture, which in Uganda is known as the Kafuan.

Site (*B*).—This is markedly unlike site (A) in that it presents a buried floor (ancient surface) situated a few feet below the sloping ground to the east of the road near the railway line, and between it and the town. Through this site a spruit has excavated an interesting section, the sequence of which is shown on the accompanying diagram (see Plate XXI). Only one tool was obtained from the section. It was recovered from the rubble layer, and on account of its patination, weathering, and form it must be regarded as belonging to the pebble series. Several flakes were recovered from the bed above the rubble. Nearer the railway station than the cutting, and between it and the road, is a "washaway" exposure where, in consequence of the removal of surface soil and other light material, stone tools can be gathered without excavation. These are typically Le Moustier in form, but are associated with certain large artifacts such as characterise the Le Moustier facies of Uganda, which is called *Sangoan*. The "Mousterian" tools are apparently derived from a continuation of bed D of the section.

5. The Uganda Sequence.

Before passing on to deal with the artifacts collected at Belfast, it is desirable for comparative purposes to consider very briefly the Stone Age sequence in so far as it has been worked out in Uganda.

The oldest-known tools in Uganda represent a pebble culture, and the artifacts themselves are to be recovered from certain river gravels. They have been chiefly studied in the Kafu basin (Bunyoro), and for this reason the culture is known as *Kafuan*. The Kafu River is associated with five distinct gravel deposits, which are of peculiar interest in that they have suffered from earth movement in almost recent times, so that the deposits are warped and do not maintain a constant—or nearly constant—level above the stream. They are named, however, from their altitude in relation to the river near the Kafu bridge (31° 27′ 30″ E. long., 1° 18′ 30″ N. lat.). Thus one speaks of them as the 225-foot, the 170-foot, the 50-foot, the *Kafu-flat*, and the *sub-flat* gravels. Above the 225-foot terrace there is a peneplain known as the 245-foot level. The peneplain, like the gravels, is warped. It is not known to carry stone tools, nor is the 225-foot terrace, but the 175-foot, the 50-foot, and the flat * yield artifacts of a pebble culture which becomes increasingly advanced in type as the lower levels are reached. The term Kafuan embraces the whole industry. The tools of the Kafu-flat level clearly foreshadow a culture of Le Moustier facies, which is well

* It is probable that the sub-flat gravels carry tools; but as these deposits are only known from boring, their implementiferous nature (or otherwise) remains undetermined.

developed in some parts of the country. This has certain peculiarities, among which may be mentioned the occurrence of massive *coup-de-poing*, giant scrapers, and some other still more characteristic tools. It is known from its type station (Sango Hill, at the extreme south-east of Uganda) as *Sangoan*.

It is possible that the culture of the Kafu-flat level is in reality very early Sangoan, and that it lacks the bigger tools for the reason that material from which they could have been made was not available in the area. It should be noted that the Kafu-flat cultures included *coup-de-poing* or semi-*coup-de-poing*, if one may employ such a term, of a very crude nature. These, too, are made from pebbles. The true Sangoan is a flake, not a pebble culture.

A later development, which in its earlier phases shows Sangoan influence, is the *Magosian*. This is essentially a microlithic industry, and is named from Magosi in Karamoja.*

At the present moment it is not possible to date these industries with any assurance. It seems not improbable, however, that the latest Magosian is but a few thousand years old, the Sangoan contemporaneous with a pluvial period associated with the Würmian glaciation of higher latitudes, and the Kafuan pre-Würmian.†

A Memoir dealing with the geology and pre-history of the Kafu area is in preparation in the offices of the Geological Survey of Uganda. In that publication the various types of Kafuan tools will be illustrated photographically.

6. The Pebble Artifacts from Belfast.

These can be grouped under six general headings, as follows: Cores, Flakes, Hammer-stones, Cutters, Scrapers, and Points. All have been made from a fairly close-grained quartzite, and all are similarly weathered and patinated a nut brown.

Cores.—The cores aré of two types, one is an irregular mass left after a number of flakes have been removed from a large pebble—usually from one side only. Some of the supposed cores may be unfinished tools (figs. 1 and 2).‡ The other type of core is a thick central slice of a pebble left when two pebble-cutters (see below) have been removed from it (fig. 3). Both types are well known from the Kafuan. Indeed, all the artifacts described in this section are common to Belfast and the Kafu.

* The approximate position of Magosi is 34° 33″ E. long., 2° 50′ N. lat.

† Wayland, E. J., "Research Note, No. 9," Ann. Rep. Geol. Surv., Uganda, for 1927, p. 34.

‡ For comparative purposes I have, in some cases, produced illustrations of Kafuan artifacts from Uganda.

Flakes.—These are either somewhat irregular, as shown in fig. 4*c* and 4*d*, or approximately oval in plan. The oval form is essentially a single flake, but is probably a tool. The sharp edges of these flakes, when fresh, would make admirable knives. Frequently one finds such flakes with broken edges (fig. 4*a* and 4*b*), and rarely one which has been trimmed. I regard this form of flake as a knife, made in a moment, used for some immediate purpose, and cast aside. I call it the *pebble-cutter*.

Hammer-stones.—These are the usual end-battered pebbles, and call for no special description.

Cutters.—In addition to the pebble-cutter there is another form (the *segmental-cutter*), a more substantial tool, but none the less simply made. Whereas the pebble-cutter is produced essentially by a single blow, the segmental-cutter is produced by two, which result in fractures meeting at an angle approximating, as a rule, very closely indeed to 30°. In some cases more than two fractures have been employed to achieve this end. It will be noticed (fig. 5) that this is a backed tool, the " backing " being part of the cortex of the pebble.

It is not improbable that any sharp-edged flake may have been used as a cutter, and that a blunted pebble-cutter would be employed as a scraper.

Scrapers.—These can be subdivided into two main types: the usual side- and end-scrapers, and steep-sided core-scrapers, or planes.

Side-scrapers.—These are long flattish pebbles trimmed along the periphery from one side only; and *end-scrapers* are, *mutatis mutandis*, similar tools (figs. 6 and 7), except that very rarely they are trimmed from both sides of the same edge. Only straight pebble-scrapers are known from Belfast at present, but hollow end- and side-scrapers are also known from the Kafu area.

Core-scrapers.—Curiously enough, very steep-sided (undercut) core-scrapers occur among the earliest known tools (those from the 175-foot level) in the Kafu area. The core-scrapers as yet recovered from Belfast are not so steep as some of the Uganda examples, but they can be matched by material from the Kafu (fig. 12). Among the Kafuan implements are double core-scrapers, that is to say, core-scrapers worked from two bases produced at right angles to each other on the same pebble.

Pebble-base Scrapers.—These curious tools are characteristic of the Kafuan, and also occur at Belfast. They resemble small *coup-de-poing*, except that they are worked from one side only. They are worked all round and all over one face, except at the base. They are commonly very thick. Fig. 13 represents a quartzite pebble-base scraper from Belfast, while fig. 14 is that of a rather flat chert pebble-base scraper from Uganda.

Points.—These can be divided into three main types, the simplest of which is the *end-point*, one of which, from Belfast, is rather diagrammatically

illustrated by fig. 8. The end-point is a common tool both at Belfast and in the Kafu area. It is invariably made by delivering a few blows along the length of a pebble from one of its ends, quite frequently the tool is finished off by means of an oblique blow delivered from the pointed end along the ventral surface (fig. 9).

Another form is that of the *shouldered pebble-point*, which is made or finished off by blows delivered on one of the faces of a pebble (figs. 10 and 11). Still another form is the *beaked-point*, this has been produced in two different ways, both of which are illustrated by material from Belfast and the Kafu.

In one (fig. 15) the base (or ventral surface) is produced by cleaving a pebble more or less in half; a beaked form is then presented by the remaining surface of the pebble after two sides (lateral surfaces) have been produced by cleavage or repeated flaking. In the other form (fig. 16) a flat pebble has been chosen, its large surfaces are left untrimmed and one side of the pebble is chipped to form a base. The curved edge of the pebble opposite this base functions, as in the type already described, as a beak. In some instances the beak is undercut.

In addition to the above described artifacts several others occur in the Kafu area, such as, for example, small tools resembling *coup-de-poing* worked all round but on one face only, borers, chopping- or smashing-tools, round scrapers (some with a characteristically cleft back),* oblique scrapers, and some other forms. The absence of these from the collection here dealt with may not be taken to indicate that they do not occur at Belfast. The writer's examination was cursory, and it is probable that continued search will bring to light additional types.

7. Artifacts of Le Moustier Affinities from Belfast.

These consist of thoroughly typical tortoise cores (struck and unstruck), Lavellois flakes, Mousterian points, Racloir and other scrapers and cutters, and, as in the case of the Le Moustier facies of Uganda, these are associated with certain large artifacts, which, unlike those listed above, are core-tools.† Not all the types of core-tools known to be associated with the Le Moustier forms of the Uganda-Sangoan culture have been found

* The cleavage is produced by delivering a blow along the length of the pebble and parallel to one of its flat sides, so as to reduce the thickness of the stone before the scraper is worked on to it. Sometimes the pebble is cleft in half by this means, but usually a plunger flake-scar results.

† Some of the Sangoan types of core-tools are described and figured in "Some Primitive Stone Implements from Uganda," Occasional Paper, No. 1, Geol. Surv., Uganda, 1923.

at Belfast, but in this case, no less than in that of the pebble-tools, much more investigation is needed before one can assert that the as yet unfound types are really missing from the culture. All the "Mousterian" material at Belfast is unpatinated, and, even in the case of the core-tools, pebbles have not been employed as raw material for the manufacture. Rounded water-worn stones were, however, used as hammers, and it is to be noted that a typically patinated pebble-tool, which had been so used, was found. The two large core-tools discovered to be associated with the flake industry (Le Moustier facies) at Belfast were the thick ovate illustrated by fig. 17 and the squarish steep-sided scraper represented by fig. 18. Both are thoroughly typical of the full Sangoan of Uganda, as indeed are the Le Moustier-like tools listed above.

8. The Relative Ages of the Belfast Artifacts.

The fact that practically all the pebble-tools, though very primitive, were found on the surface, while all the artifacts of the Le Moustier facies collected by the writer came from below ground, would appear to indicate that the latter are the older. This, however, I believe is not the case, for the following reasons :—*

1. The tools of Le Moustier facies are unpatinated, while those of the pebble series are deeply patinated.

2. One patinated pebble-tool has been used as a hammer-stone by the people of the flake industry. It would thus appear to be a "derived" tool of older date than those of the Le Moustier facies.

3. Another derived tool, similarly patinated, was found in a rubble layer on an old land surface (see diagram), while only a few inches higher up in the same section, and distributed through the soil surfacewards, were many completely unpatinated flakes.

The tool from the rubble layer is shown in fig. 19. It is very similar to, though not exactly like, the double planes found in the Kafuan. Nearly all the cortex has been trimmed off this artifact ; some are shown to the left of the face depicted in fig. 19*a*. The back (right side of 19*b*) is a flake-scar, and so is most of the base. Held in such a position that the left side of fig. 19*a* is bottommost, the tool resembles a broken *coup-de-poing*, but the manner in which three large flakes have been removed to form the base (one flake) and the side (two flakes) shows that this is not so.

* It is to be noted that tools of the flake industry are to be picked up on the surface here and there just as pebble-tools are.

9. Correlation.

The writer feels little doubt that the Le Moustier type of industry found at Belfast is the cultural equivalent of the Sangoan of Uganda; and similarly that the Belfast pebble industry is the equivalent of one stage or other of the Kafuan. Detailed studies must be undertaken, however, before the degree of parallelism between the flake industry of the Transvaal and the Sangoan of Uganda can be established, and before the particular stage of the Kafuan represented by the Belfast pebble culture becomes determinable.

The writer does not propose to make any attempt here to date the artifacts described in this paper; for to do this one would need to assume that the cultural equivalents above dealt with were contemporaneous in widely separated areas in Africa—they may well have been so, but evidence on this point is lacking at present. Moreover, assuming contemporaneity, the dating would be made to depend on evidence gathered in Uganda, which it would be out of place to discuss.

It is suggested that the study of past climates may possibly help in the matter of age correlation. Among other points calling for determination is the relationship of the pebble-tools to the "laterised" soils. It is not unlikely that pebble-culture man lived in primeval forests, and that he collected the raw materials for his implements from the streams. The forests are gone, perhaps with the passing of a period of much rain. Old soils have been scattered broadcast by the winds of later times, which have thus exposed, in places, the handiwork of a long-forgotten race.

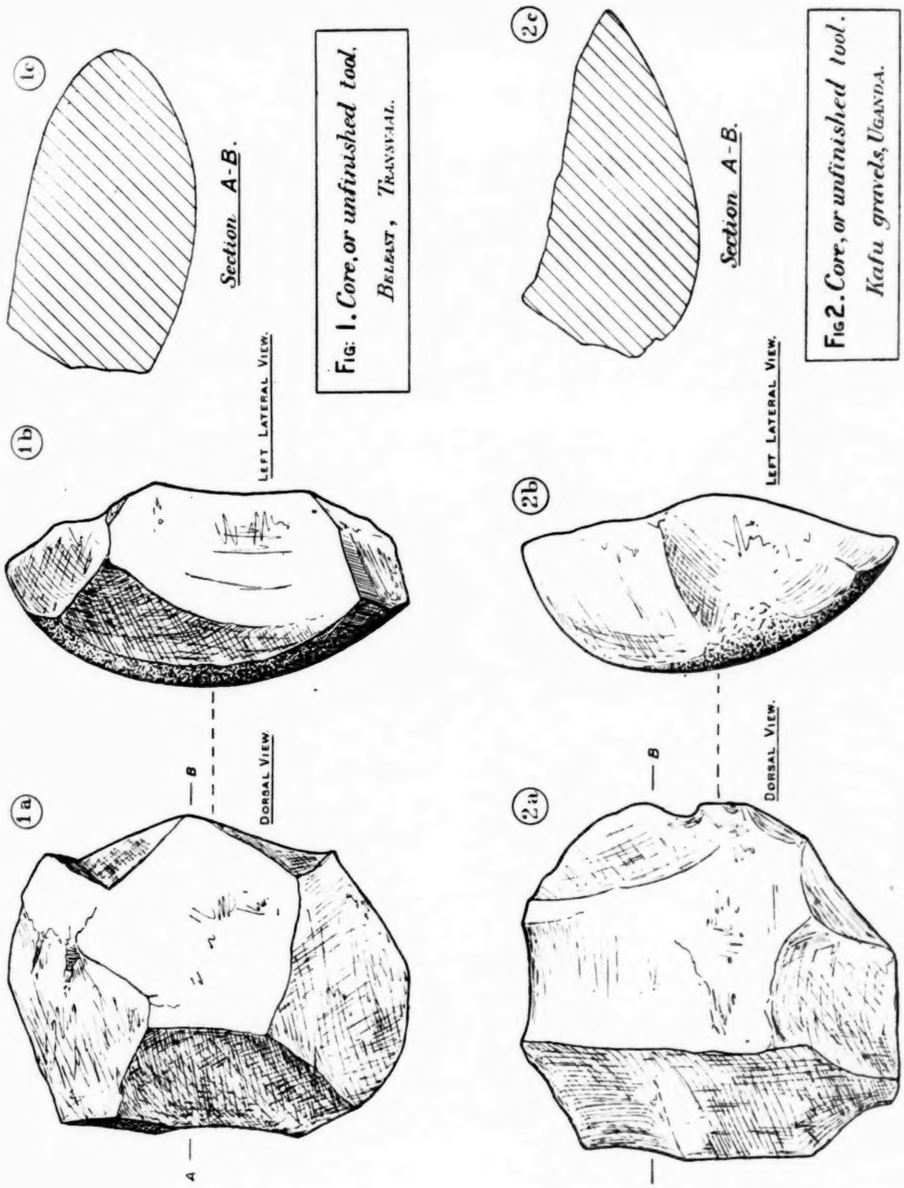

Fig: 1. Core, or unfinished tool, Belfast, Transvaal.

Fig 2. Core, or unfinished tool. Kafu gravels, Uganda.

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Fig 3. *Slice core*
BELFAST,
TRANSVAAL.

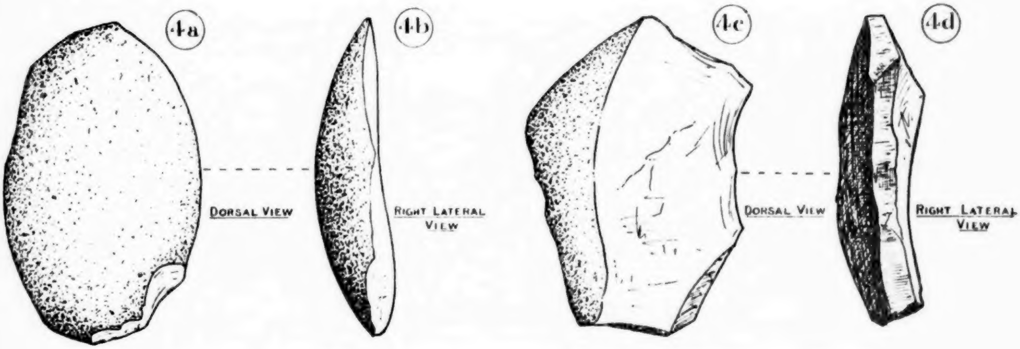

Fig 4. *Pebble flakes*, BELFAST, TRANSVAAL.

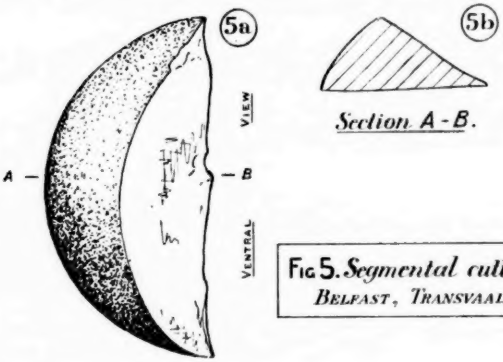

Fig 5. *Segmental cutter.*
BELFAST, TRANSVAAL.

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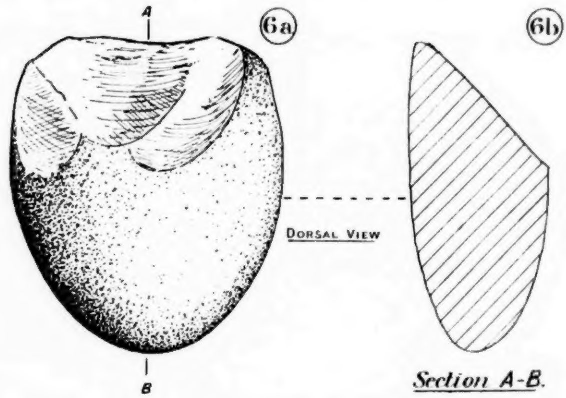

Fig 6. *Straight end scraper,*
Belfast, Transvaal.

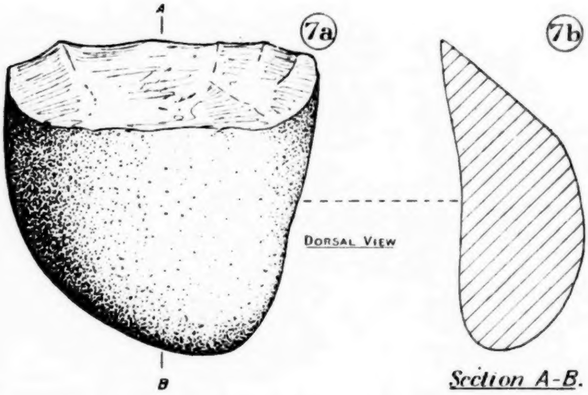

Fig 7. *Straight end scraper;*
Kafu gravels, Uganda.

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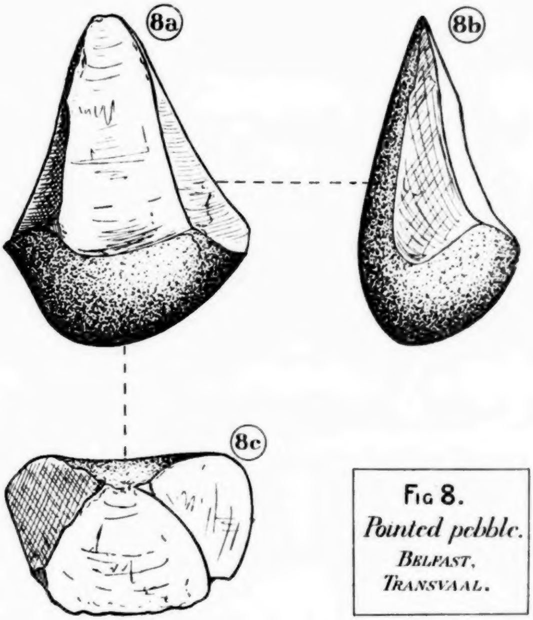

FIG 8.
Pointed pebble.
BELFAST,
TRANSVAAL.

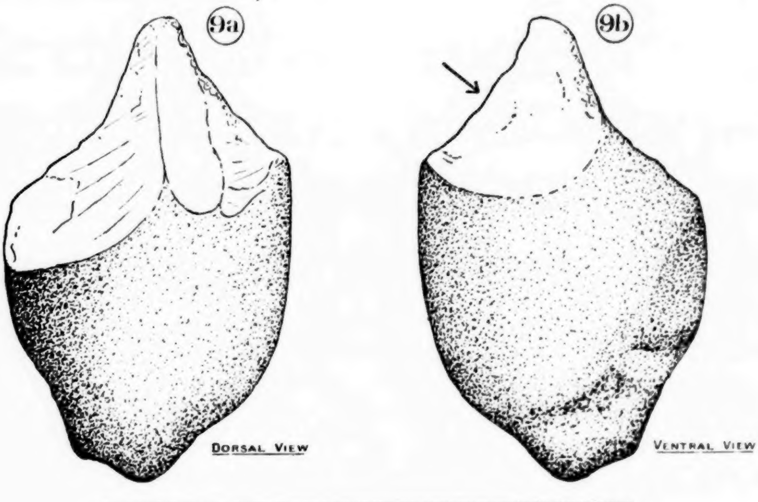

FIG 9. *Pointed pebble, Kafu gravels* UGANDA.

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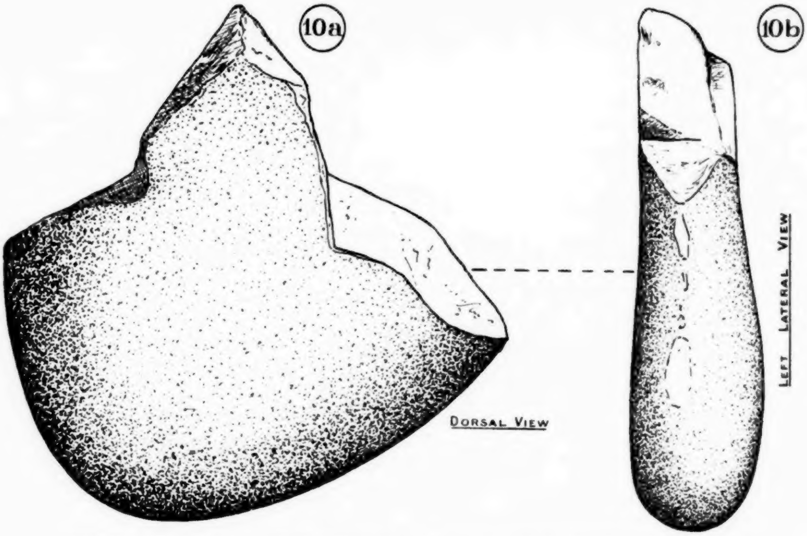

Fig 10. *Shouldered pebble-point*, Belfast, Transvaal.

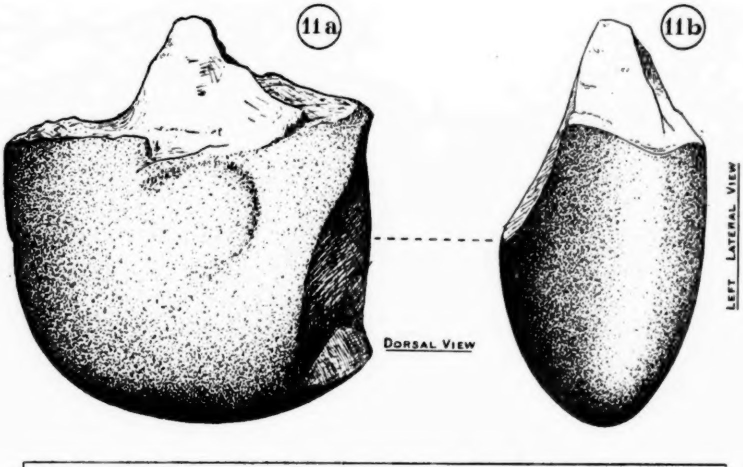

Fig 11. *Shouldered pebble-point*, *Kafu gravels*, Uganda.

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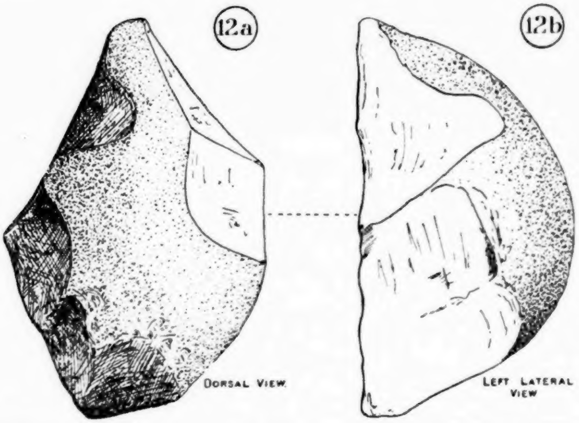

FIG 12. *Steep-sided scraper,* BELFAST. TRANSVAAL.

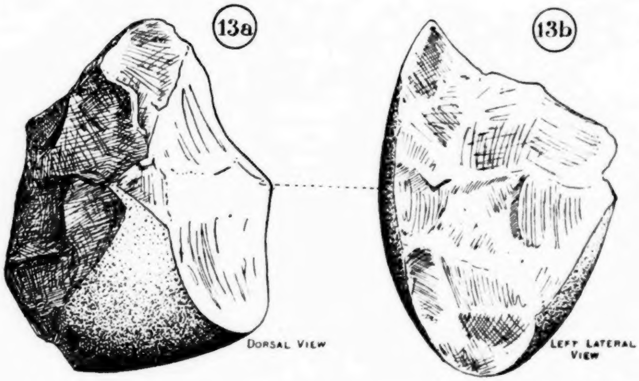

FIG 13. *Pebble base scraper,* BELFAST, TRANSVAAL.

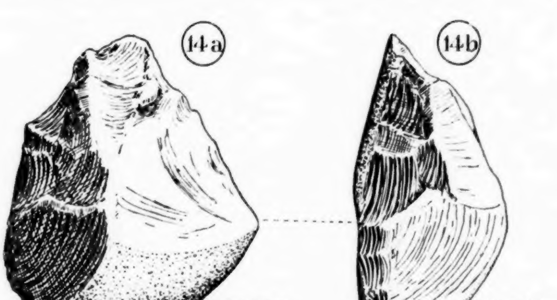

FIG 14. *Pebble-base scraper, Kafu gravels,* UGANDA.

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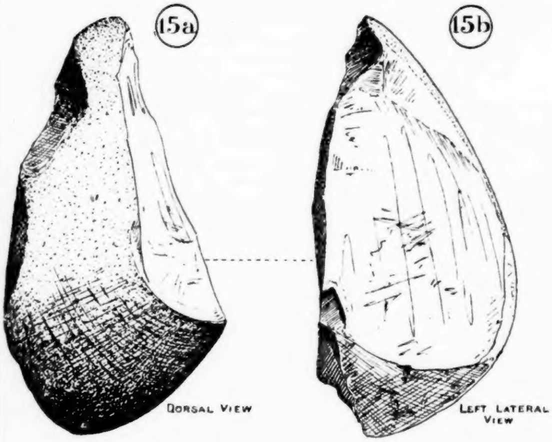

FIG 15. *Beaked point*, BELFAST, TRANSVAAL.

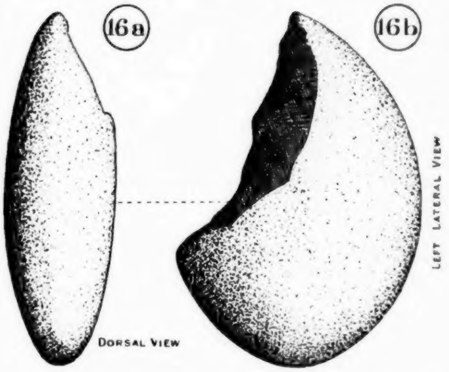

FIG 16. *Beaked point*, *Kafu gravels*, UGANDA.

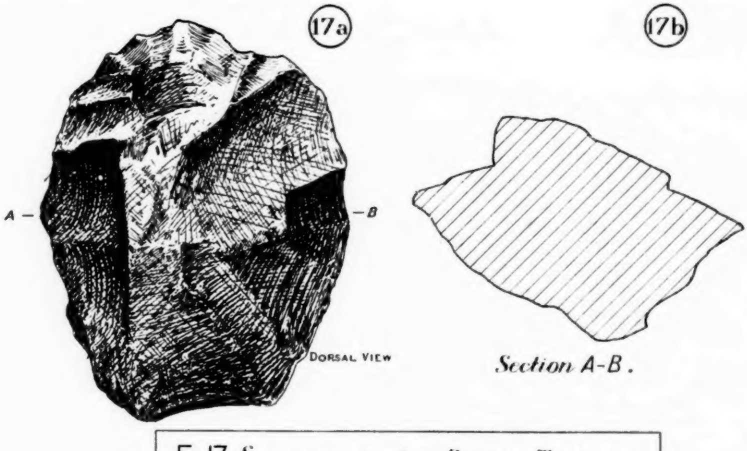

FIG 17. *Sangoan ovate*, BELFAST, TRANSVAAL.

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Trans

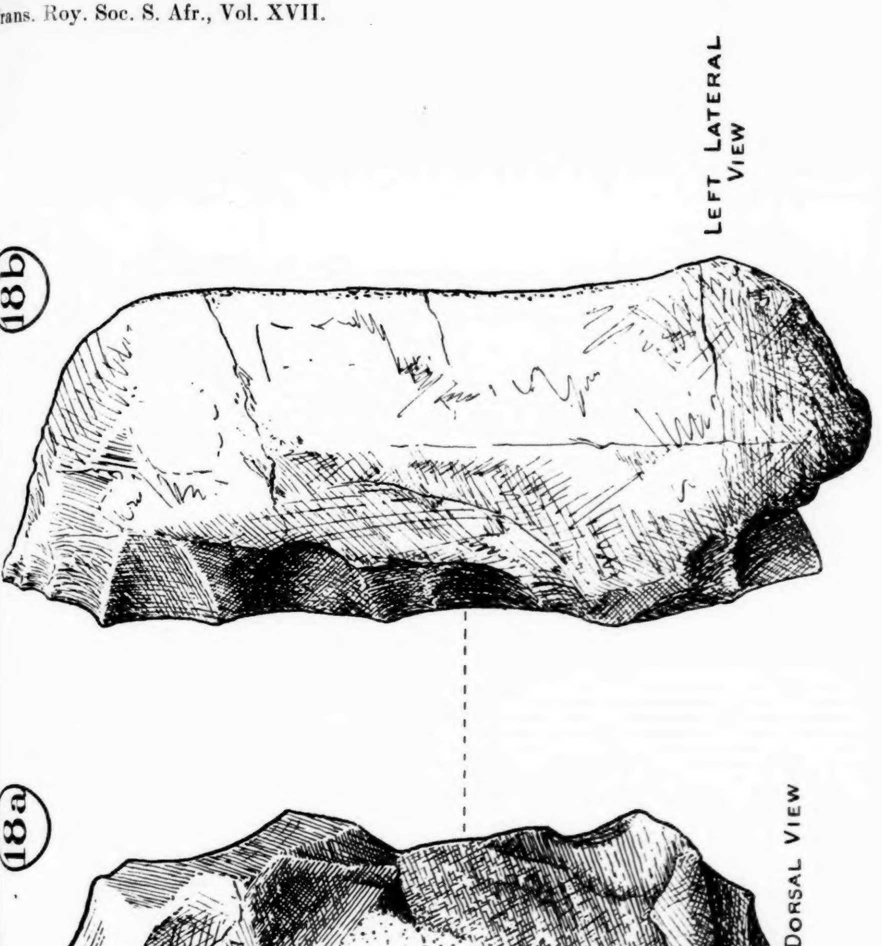

Fig 18. *Steep-sided scraper of Sangoan type*, Belfast, Transvaal.

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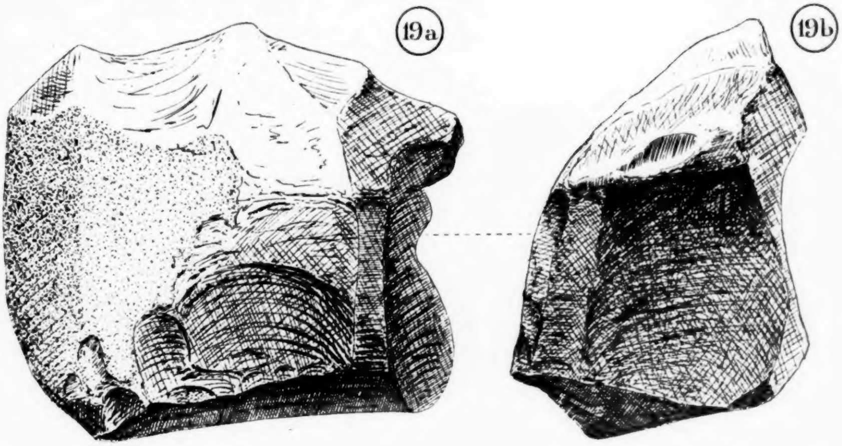
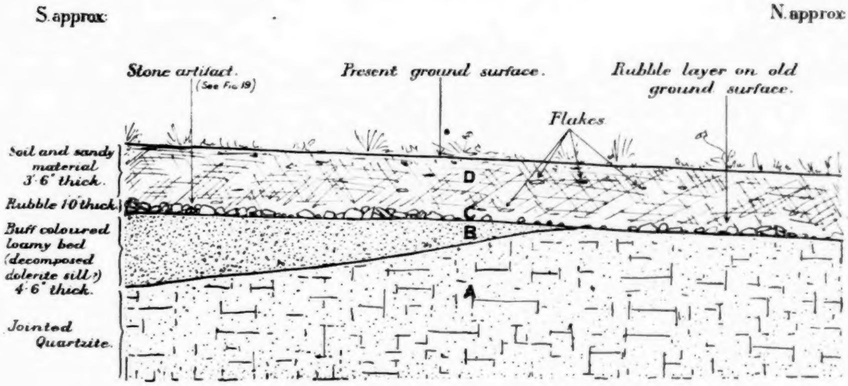


FIG 19. *Supposed double steep-sided scraper (plane) from layer on buried land surface, BELFAST, TRANSVAAL.*



Diagrammatic Section shewing a buried Stone-age Land Surface near Belfast Railway Station, TRANSVAAL.

Neill & Co., Ltd.

CONTRIBUTIONS TO A KNOWLEDGE OF THE TRANSVAAL IRIDACEAE.

By N. E. Brown, A.L.S.

(Communicated by J. Burtt Davy, M.A., Ph.D.)

Having been invited by Dr. Burtt Davy to undertake the working out of the Iridaceae for his Manual of the Flowering Plants and Ferns of the Transvaal, the author realised that this could not be satisfactorily accomplished without first making a critical study of the types preserved in the older herbaria, especially those of Linné, Burmann, and Thunberg, upon which the foundation of our knowledge of South African Iridaceae is based, in order to ascertain the precise specific limits of the species to which Transvaal specimens have been referred. This could not be determined from the *Flora Capensis*, and it appeared to the present author to be very doubtful if any Transvaal species was known to the older authors. The examination of these collections involved an expenditure of several months' time and labour, for it is an exceedingly difficult group to study from dried material. But heavy as the task has been, it warranted the time and labour spent on it, for it has been both fruitful and fundamental in character, very many misidentifications having been discovered, and much important information obtained concerning species growing in other parts of South Africa, which should free the determinations of some species from ambiguity and lighten the future tasks of local botanists.

The present contribution deals with new species of that group of Irids known as "Tulps," whose poisonous character is well known in South Africa. Dr. Burtt Davy has informed the author that though much has been written concerning them, owing to a lack of knowledge of the specific limits of the whole group it has been impossible hitherto properly to correlate the information obtained, with certain definite species. The want of means of correctly determining the species concerned may account for a certain amount of inconclusive evidence as to the poisonous or non-poisonous nature of "Tulps" from certain areas. With a means of more correct identification of the species it should become possible to determine with precision which are poisonous and which—if any—are innocuous, and whether the different species differ in their degree of toxicity. It is probable, however, that there are several more species of this group in the Transvaal than is suspected, for some species are so similar to others in

foliage and flowers that their distinctive characters have either been overlooked or not appreciated. From dried material they cannot be determined unless the flowers are so carefully dried that the shape and colour of the various parts can be well seen. Living flowers of every species should be carefully dissected, and the parts dried separately and properly labelled and numbered, so that confusion with flowers of another species may be avoided.

It is to be hoped that an effort will be made by South African botanists to ascertain whether the "Transvaal Yellow Tulp," from which Dr. Rindl obtained the poisonous alkaloid Homeridine described in these Transactions (vol. xi, pp. 251–256), really is *H. pallida*, and if not, then to which species it should be referred; because, as noted further on, the present author finds that the Yellow Tulp described and figured in Bulletin No. 6 of the Union Department of Agriculture, Division of Botany, as *Homeria pallida* is not that species. Also that, if that figure is correct, it appears to represent a new and undescribed species, of which good material is desired for description.

In addition to the *Homerias*, certain species of *Morea* (an allied genus having white, blue, or purple flowers) are considered highly poisonous, and Dr. Burtt Davy informs the author that some stockmen claim that they are more poisonous than the yellow-flowered tulps. On the other hand, certain species are said to be harmless. When the revision of the group is complete it should be possible to clear up any uncertainty connected with these points.

The species herein described are all represented at Kew.

Key to Four of the Transvaal Genera of Iridaceae.

a. Stamens placed behind (or more or less hidden under) the style-arms, which are mostly broad and flat or petaloid; perianth-segments nearly free, being only united into a mere ring at the base; no distinct tube, *b.*

b. Leaves laterally flattened (iris-like); rootstock stout, creeping and rooting, not bulbous; flowers iris-like, with the inner and outer segments dissimilar (1) *Dietes.*

b. Leaves flattened from above and channelled down the upper side, or semiterete or terete; rootstock a corm (solid bulb) covered with fibres, *c.*

c. Ovary and the thin membranous capsule subsessile, concealed in the bracts of the flower-clusters and produced into a long slender beak, like a pedicel, on which the flower is exserted; flowers iris-like . . . (3) *Helixyra.*

c. Ovary and the firm capsule more or less exserted from the flower-clusters on a long pedicel; capsule without or rarely with a very short beak, *d.*

d. Lobes of the style-arms conspicuous, petaloid, as broad as or broader than the transverse stigmas under their base; flowers iris-like, with the inner and outer segments dissimilar in colour and form or size; filaments free or more or less united into a sheath around the style . . . . . . (2) *Morea.*

d. Lobes of the style-arms reduced to short subulate points, narrower than the transverse or oblique stigmas under their base; outer and inner perianth segments similar in form, size, and colour (except in two Cape species) (4) *Homeria.*

1. Dietes, Salisbury.

Rootstock a stout, creeping rhizome. Leaves 4–10 to a growth, in 2 ranks, laterally flattened, linear or sword-shaped, and abruptly narrowed on the upper edge at the basal part; flower-stem simple or branched, with 1 or more flower-clusters; perianth segments free almost to the base, spreading from the base, no distinct claw, the outer broader than the inner; style none or exceedingly short; style-arms very broad and petaloid, deeply 2-lobed at the apex; stigmas transverse, about half as broad as the lobes of the style-arms; ovary and fruit exserted from the flower-clusters.

This genus has not hitherto been properly characterised, and in *Fl. Cap.*, vi, 25–26, all the Kew material was referred by Baker to only two species and one variety. The following is the only representative of the genus yet found in the Transvaal.

1. **D. prolongata** var. **Galpini,** N.E. Br.—Flower-stem 30–60 cm. long, erect, not producing young plants at the nodes; flowers 4–5 cm. in diam., white, without a central spot on the outer segments.—Barberton *Galpin* 1206! type; Woodbush *Rehmann* 5771!; Shilouvane *Junod* 1215! (Endemic).

2. Morea, Miller.

As the spelling of this generic name, as here adopted, is different from that which has hitherto been used, it is necessary to explain that the genus was founded and well described and figured by Miller in his Figures of Plants, ii, 159, t. 238, published in the part of that work issued on 27th June 1758, and that the name Morea was there given "in Honour of Robert More Esquire of Shropshire." In 1762 Linné accepted Miller's genus as valid, but (doubtless by some mistake) altered the spelling to Moraea, an erroneous form which has ever since been followed, but for which there is not the slightest justification. In all probability, when he made this error Linné had his wife's maiden name, Moraeus, in his mind, the pronunciation being somewhat similar, thus causing him to misspell Miller's generic name; as he accepted that name as being Miller's genus (see Linn. Gen. Pl., ed. vi, p. 27) there is no justification for any alteration in the spelling of it.

Key to the Transvaal Species of Morea.

a. Plant with 3 developed leaves and 3 to 10 flower-clusters to a stem, the upper leaf under the lowest flower-cluster; stem (including flowers) 17–45 cm. high; lower leaves 50–65 cm. long, 5–7 mm. broad, linear, acute; clusters 4–5 cm. long; outer petal of dried flowers about 30 mm. long, not bearded, purple; stigma-appendages 1 cm. long, acute . . . . (5) *polystachya.*

a. Plant either with only 1 developed leaf to a stem or leafless at the time of flowering, the other stem-leaves being reduced to sheaths, *b.*

b. Outer petals of dried flowers 4–7·5 cm. long; leaf basal or absent at the time of flowering, very long; flower-clusters solitary, terminal; flowers yellow (but see note under *M. Muddii*); outer petal not bearded, *c.*

c. Corm bearing a mass of long blackish fibres around the base of the stem, *d.*

d. Leaf 5–7 mm. broad, linear, flattish-concave, or perhaps somewhat folded lengthwise, and then about 4 mm. broad; stem (with flowers) 45–65 cm. high, 3–5 mm. thick; flower-clusters 10–13 cm. long; outer petals 5–6 cm. long; stigma-appendages 15 mm. long; bulb-fibres 10–15 cm. long. . (2) *Moggii.*

d. Leaf 2 mm. or less broad or thick, terete, with a narrow groove down the face; stem (including flowers) 20–24 cm. high, 1½–3 mm. thick; flower-clusters 7–9 cm. long; outer petals 4½–5 cm. long; stigma-appendages about 1 cm. long; bulb-fibres 7–9 cm. long . . . . (3) *Galpini.*

c. Corm without a mass of long fibres around the base of the stem and leaf (but not seen in *M. Muddii*); flowers yellow.

Stem (including flowers) 37–45 cm. high, 2·5–3 mm. thick; leaf 28–40 cm. long, 2·5–6 mm. broad, linear, acute, equalling or overtopping the flowers; flower-clusters 10–11 cm. long; outer petals 4–4·5 cm. long; stigma-appendages 10–12 mm. long, ... (4) *Muddii.*

Stem (including flowers) 60–100 cm. or more high, 4–10 mm. thick; leaf 120–160 cm. long, 10–25 mm. broad, linear, acute, overtopping the flowers; flower-clusters 13–15 cm. long; outer petals 7·5 cm. long; stigma-appendages 2 cm. long, ... (1) *spathulata.*

b. Outer petals of dried flowers 1–2·5 cm. long, *e.*

e. Inner petals trifid; staminal filaments united for most or nearly all of their length into a tube around the style (§ Vieusseuxia), *f.*

f. Claw of petals puberulous outside; leaf about 50 cm. long, 3 mm. broad, linear, glabrous; stem branched above and bearing 2–4 erect flower-clusters 6–7 cm. long; flowers blue: outer petals about 2·5 cm. long; inner petals 1·8 cm. long, trifid, the middle lobe filiform, the lateral lobe with a narrow petaloid wing on the outer side, ... (15) *pubiflora.*

f. Claw of the petals glabrous outside; outer petal 1·8–2 cm. long; flower-cluster solitary, terminal, *g.*

g. Plant 15–18 cm. high; stem about 1 mm. thick, leafless at time of flowering; flower-clusters 3–3·5 cm. long; flowers quite glabrous; inner petals 9–10 mm. long, the middle lobe filiform, the lateral lobe much shorter and broader . . . . (14) *Marionae.*

g. Plant 30–35 cm. high; stem less than 1 mm. thick, leafless at the time of flowering; flower-clusters 4–4·5 cm. long; inner petals about 12 mm. long, all the lobes apparently filiform . . . . (16) *exilis.*

g. Plant 35–55 cm. high, 1·25–1·5 mm. thick, with one of the lower sheaths produced into a linear leaf 9–10 cm. long with incurved edges; flower-cluster 5–6 cm. long; outer petals with puberulous blades; inner petals about 13 mm. long, middle lobe filiform, lateral lobe very much shorter and broader, falcate . . . . (17) *Rogersii.*

e. Inner petals entire (to end), *h.*

h. Plant always with one leaf when flowering, *i.*

i. Leaf close under or only a little below the flowering part of the stem, *j.*

j. Leaf equalling or overtopping the flowers by not more than 10–12 cm., subulate (from the margins being inrolled), and in that condition 1–1·5 mm. broad at the base; flower-clusters 1–2 to a stem, 3–4 cm. long and 2–4 mm. thick; flowers of some shade of blue or purple; outer petals about 16–19 mm. long and 6–7 mm. broad; stigma-appendages 6–7 mm. long . . . . (6) *Elliottii.*

j. Leaf overtopping the flowers by 25 cm. or more, 1 mm. or less thick, filiform, with a narrow groove down the face, very finely striate; inflorescence 6–8 cm. long, simple, slender, somewhat zigzag, with 2–3 superposed flower-clusters 2–2·5 cm. long; flowers small, colour not stated; outer petals of dried flower about 1 cm. long and 3 mm. broad; stigma-appendages not seen . . . . (7) *parviflora.*

i. Leaf near the middle or towards the base of the stem, some distance below the flowering part, and with barren sheaths on the stem above the leaf, *k.*

k. Stem bearing 2 or more flower-clusters; leaf overtopping the flowers, terete, (10) *trita* var. *foliata.*

k. Stem bearing only 1 flower-cluster, which is terminal; leaf overtopping the flowers, terete, *l.*

l. Leaf 37–47 cm. long, scarcely or not more than 1 mm. thick; flower-clusters 4–5 cm. long, the outer bracts acuminate, brownish, often with the point breaking up into fibres; "flowers deep lilac-purple with spotted segments"; outer petals about 2 cm. long; filaments of the stamens 3 mm. long, free at the upper half . . (8) *juncifolia.*

l. Leaf 30–40 cm. long, 1–1·5 mm. thick; flower-clusters 4·5–5·25 cm. long, the outer bracts acuminate, green with brown tips and margins, the point not breaking up into fibres; outer petals 22–26 mm. long, about 10 mm. broad, blue, with a yellow mark on the claw that apparently fades into a paler colour above and is surrounded by a dark blue line; inner petals about 4 mm. broad, linear-lanceolate, blue (9) *Stewartae.*

h. Plant 10–30 cm. high, leafless at the time of flowering; stem slender, 0·7–1·5 mm. thick, bearing only barren sheaths below the inflorescence; flower-clusters 2–4 to a stem, superposed in a terminal straight spike, *m.*

m. Outer petals 15–19 mm. long, 4–6 mm. broad; inner petals 13–16 mm. long, 1·5–2·5 mm. broad, *n.*

n. Style-arms 2–2·5 mm. broad at the base, narrowing upwards; outer petals (as seen in formalin) pale yellow (but perhaps pale blue), with a midline crossed by an arched mark of darker yellow at the base of the limb (11) *parva.*

n. Style-arms 1·5 mm. broad, linear scarcely narrowing upwards; outer petals pale blue, with a yellow spot at the base of the limb . (12) *Mossii.*

m. Outer petals 20–22 mm. long and about 6 mm. broad; inner petals 17–18 mm. long and about 2 mm. broad (flowers not dissectable), *o.*

o. Flowering part of stem 4–7 cm. long; bracts 25–30 mm. long; veins of the outer bracts 4–5 in the space of 1 mm.; Shilouvane (13) *stricta.*

o. Flowering part of stem 7–12 cm. long; bracts 30–40 mm. long; veins of outer bracts about 3 in the space of 1 mm.; Lydenburg . (10) *trita.*

1. **M. spathulata** Klatt; *Iris spathulata* L.f.; *I. spathacea* Ker; *M. spathacea* Ker; *M. rivularis* Schlechter.—Pretoria; Strubens Farm *Mogg*! Middelburg; Belfast *Franks*! Barberton district *Galpin* 815! Rogers 21048!

Lydenburg: Sabie *Rogers* 24773! *Moss* 2894! Swaziland; Hlatikulu *Stewart* 47! Tzaneen *Rogers* 18834! (O.F.S.! Basutoland! Natal! and southward to George Div.!).

There may possibly be more than one species included under this name, but I am unable to distinguish them among the dried material before me. They require to be studied in the living state. Schlechter distinguishes **M. rivularis** by its basal sheath being entire and the presence of a brownish-violet mark upon the style-arms, but the character of the basal sheath being entire or broken up into fibres appears to be variable.

2. **M. Moggii** N.E. Br.—Pretoria: Strubens Farm *Mogg*! type; (Endemic).

3. **M. Galpini** N.E. Br.; *M. spathacea* var. *Galpinii*, Baker.—Plant leafless at time of flowering. Mountains around Barberton, flowering Aug.–Sept., 4700–5000 ft. alt., *Galpin* 459! *Rogers* 21628! Thorncroft! (Endemic).

4. **M. Muddii** N.E. Br.—Lydenburg: Macmac *Mudd*! type; between Pilgrims Drift and Sabie, 3500 ft. alt., *Rogers* 23152! Sabie Valley *Gray*! (Endemic).

5. **M. polystachya** Ker. Stem to the base of the lowest flowers 19–30 cm. high; bracts with rather long awn-like points.—Bloemhof: Cawoods Hope *Burtt Davy*! Kaffraria near Christiana *Burtt Davy*! Vierfontein near Schweizer Reneke *Burtt Davy* 1629! Locality? *McLea* in hb. Bolus 5789!—Flowering Feb.–Apl.

Var. **brevicaulis** Stent in Bull. Dept. of Agr. Pretoria, No. 6, 1922, fig. only, no text. Stem to the base of the lowest flowers 10–15 cm. high; bracts with short awn-like points.—Bloemhof: Cawoods Hope *Burtt Davy*! Pretoria *Stent*!—Flowering Feb.–Apl. (Griqualand W.! Graaff Reinet! Somerset! Queenstown! Albany!).

6. **M. Elliottii** Baker.—Carolina: marshes near Lake Chrissie *Scott Elliot* 1592! type; Carolina *Rogers* 19547! 19675! *Moss and Rogers* 1076! (Endemic).

7. **M. parviflora** N.E. Br. Stem with flowers (and excluding leaf) 45–60 cm. high, very slender, 0·7–1 mm. thick, usually twisted; leaf arising at the top of the stem, close under the inflorescence.—Waterberg: Tomsons Vlei, Nylstroom *Pole Evans* 19668! type.—Jan. (Endemic).

8. **M. juncifolia** N.E. Br. Stem with flowers (and excluding leaf) about 30 cm. high, very slender, about 1 mm. thick, very smooth and not striate except on the sheaths; leaf basal, terete, very smooth, not striate, 40–45 cm. long.—Dry grassy places on mountain sides, Saddleback Range, Barberton, 3650–3800 ft. *Galpin* 859! type.—March (Endemic).

9. **M. Stewartae** N.E. Br. Stem with flowers 30–40 cm. high, slender, 1 mm. thick, smooth, with striate sheaths; leaf arising below the middle of the stem and overtopping it, 25–35 cm. long, 1 mm. thick, terete, acute,

slightly striate.—Swaziland ; on grassy slopes, Hlatikulu *Miss Stewart* 44 ! type (Endemic).

10. **M. trita** N.E. Br. Stem leafless at the time of flowering.—Common around Pretoria *Phillips* ! *Rogers* 20440 ! *Burtt Davy* 1965 ! Carolina : Waterval Boven, *Miss Mason* 113 ! near Johannesburg ; Barberton : Nelspruit *Rogers* 21343 ! Pietersburg : Zoekmekaar *Rogers* 21498 ! near Lydenburg *Wilms* 1419 ! type.—Aug.–Sept. (Endemic).

Var. **foliata** N.E. Br. One basal leaf present at the time of flowering.—Common around Pretoria *Phillips* ! near Brakpan *Murray* 36 ! Krugersdorp *Bush* ! Johannesburg *Moss* 2877 ! between Piet Retief and Wakkerstroom *Burtt Davy* 2210 ! Lydenburg : near the Devil's Knuckles *Wilms* 1418 ! type !—Sept.–Feb. (Basutoland !).

11. **M. parva** N.E. Br. Plant 10–15 cm. high, glabrous : corm about 15 mm. diam., with fuscous pinnately divided fibres ; stem slender, 1 mm. thick, leafless when in flower, with an indication of remains of 1 filiform leaf, and bearing 1–3 flower-clusters ; bracts 2·5–4 cm. long, acuminate ; outer perianth segments 15–16 mm. long, including the claw, 4–6 mm. broad, oblong or elliptic-oblong, shortly acute, narrowed at the base into a cuneate claw 3–4 mm. long, pale yellow (see under *M. Marionae*), with a darker midline crossed by an arched mark of darker yellow at the base of the limb ; inner perianth segments 13–15 mm. long, 2·5 mm. broad, narrowly lanceolate, acute, pale yellow with a darker mark at the top of the claw ; staminal sheath 3 mm. long ; anthers 4–5 mm. long ; style-arms (including the 3–4 mm. long lobes) 7–8 mm. long, narrowing upwards from a 2–2·5 mm. broad base ; stigmas ovate, diverging.—Pietersburg Dist. : Grassveld, Woodbush Mountains *Moss* 15564 ! type (Endemic).

12. **M. Mossii** N.E. Br. Plant 12–20 cm. high, glabrous ; corm 12–13 mm. in diam. ; stem 1 mm. thick, with about 2 barren sheaths and 2–3 flower-clusters, leafless at the time of flowering ; bracts 2·5–3·5 cm. long, acute or acuminate ; outer perianth segments with a rather broad erect claw 8–9 mm. long and 2 mm. broad, and a spreading limb 7–10 mm. long and 4–6 mm. broad, ovate or ovate-lanceolate and acute to elliptic-oblong and obtuse, with pale blue a yellow spot at its base ; inner segments 13–16 mm. long, 1·5–2·5 mm. broad, linear, acute, pale blue; staminal sheath 2–3 mm. long ; anthers 4·5–6 mm. long ; style-arms (including the 3–5 mm. long lobes) 9–11 mm. long and 1·5 mm. broad, linear, scarcely narrowing upwards ; stigmas half-circular.—Grassveld near Johannesburg, flowering Sept. *Moss* 15805 type ! (Endemic).

13. **M. stricta** Baker.—Near Shilouvane *Junod* 563 ! type.—Aug. (Endemic).

14. **M. Marionae** N.E. Br. (§ Vieusseuxia). Plant about 15–18 cm. high, glabrous ; stem about 1 mm. thick, leafless at time of flowering,

with 1 flower-cluster and 2 barren sheaths below it; leaf (judging from the remains seen) apparently solitary and filiform; bracts about 3–4 cm. long, awn-pointed; outer perianth segments glabrous, with an erect claw 4–5 mm. long, and a spreading blade 9–10 mm. long and 5–6 mm. broad, elliptic-lanceolate, shortly acute, stated to be "very pale blue, almost white" when alive, but as dried when taken out of formalin appearing to be pale yellow, minutely speckled all over with a darker colour; inner segments 9–10 mm. long, erect, trifid, glabrous, with the middle lobe 4–5 mm. long, filiform, incurved, and the lateral lobes 1 mm. long, apparently of the same colour as the outer segments; style-arms overtopping inner perianth segments; linear, about 1·5 mm. broad, with the lobes 2 mm. long, and incurving.—Pietersburg: Grassveld, Woodbush Mountains, *Miss Marion E. Blenkiron* in Hb. Moss 15565 type! (Endemic).—When received in formalin all the parts of the flower were of a pale yellow colour, dotted with orange-yellow! And as they are stated to be of a very pale-bluish tint when alive, the flowers of *M. parva* (which were also sent in formalin) may likewise have been altered in colour from bluish to yellow.

15. **M. pubiflora** N.E. Br. Distinguished from all other species by the puberulous outer surface of the claws of the petals.—Swaziland: Hlatikulu, on high grassy slopes, *Miss Stewart* 36! type. Flowering Jan. (Endemic).

16. **M. exilis** N.E. Br. Flowers lilac, spotted.—Barberton Dist.: Saddleback Range, Barberton, on grassy mountain slopes, 3000–4500 ft. *Galpin* 467! type.—Aug.-Sept. (Endemic).

17. **M. Rogersii** N.E. Br.—Lydenburg: Pilgrims Rest *Rogers*! type. —Nov. (Endemic).

3. Helixyra, Salisbury.

As this very distinct genus has never been fully described I here give its characters.

Leaves 1–2 to a stem, often very long, linear and flat, or with incurved edges, or terete, sometimes spirally coiled; bracts thin, membranous when dried, with distinct veins or rarely apparently veinless; perianth segments free almost to the base, with distinct claws, entire, the inner smaller than the outer; stamens free; ovary on a very short pedicel and included in the basal part of the flower-cluster, produced above into a very long and slender beak, like a pedicel, bearing the exserted flower at its apex; style divided very deeply or nearly to its base into 3 linear or cuneate petaloid style-arms, with 2 acute lobes at the apex as broad as or broader than the (always ?) bluntly conical stigmas under their base; capsule very thin and membranous, 3-celled; seeds several in a cell, somewhat angular from mutual pressure.—*Gynandriris*, Parlatore (1854).

The plants belonging to this genus have hitherto been placed partly in the genus *Iris*, partly in *Morea*, but it differs conspicuously from both by its membranous distantly veined bracts; by the very long and slender beak to the ovary and fruit, on which the flower is borne and from which it becomes detached, and by the ripe capsule being very thin and membranous in texture and completely concealed in the flower-cluster, instead of being firm or hard in texture and exserted, as it is in *Iris* and *Morea*.

The following species outside of our area belong to Helixyra: **H. longiflora** N.E. Br., comb. nov. (*Morea longiflora* Ker); **Helixyra flava** Salisb., the type of the genus; **H. Burchellii** N.E. Br., comb. nov. (*Morea Burchellii* Baker); **H. cladostachya** N.E. Br., comb. nov. (*Morea cladostachya* Baker); **H. Rogersii** N.E. Br., comb. nov. (*Morea Rogersii* Baker); **H. setifolia** N.E. Br., comb. nov. (*Morea setifolia* Druce, *M. setacea* Ker, *M. xerospatha* Baker, *Iris setifolia* Linn. f., and *I. setacea* Thunb.); and **H. spiralis** N.E. Br., comb. nov. (*Morea spiralis* Baker), all from South Africa. And from the Mediterranean region **H. sisyrinchium** N.E. Br., comb. nov. (*Iris sisyrinchium* Linn., *Gynandriris sisyrinchium* Parl.).

Flowers are either absent, or not dissectable in the dried state, so that the above description is chiefly from flowers of *H. Mossii* sent to me in formalin by Prof. C. E. Moss. It is particularly desirable that the flowers of this genus, and of other Irids, should have their parts separately dried, so as to preserve form and colour.

Key to the Transvaal Species of Helixyra.

a. Flowering-part of the stem above the base of the leaf 15–30 cm. long; flower-clusters 3·5–5 cm. long; flowers not dissectable, *b.*

b. Flowering-part of the stem branching; branches purple, with 2–4 sessile flower-clusters arranged one above another in simple spikes; flowers apparently blue or lilac; plant 30–50 cm. high . . . . (1) *elata.*

b. Flowering-part of the stem unbranched, with about 4 sessile flower-clusters arranged one above another in a simple spike about 15 cm. long; flowers not seen; plant 25–40 cm. high . . . . (2) *spicata.*

a. Flowering-part of the stem above the base of the leaf 6–14 cm. long; flower-clusters 4–5 cm. long; plants 15–27 cm. high, *c.*

c. Flower-clusters 2–4 to a plant, when more than two the lower is on a separate branch or peduncle; flowers apparently bluish or lilac, not dissectable, but the outer segments with a claw about 9 mm. long and a blade about 11 mm. long; Bloemhof District . . . . (3) *simulans.*

c. Flower-clusters 3–5 to a plant, all sessile and clustered together or much overlapping one another; flowers not seen; Zoutpansberg . . . . (4) *propinqua.*

c. Flower-clusters 3–5, one above another in a simple spike 5–8 cm. long; flowers 18–20 mm. in diameter; claw of outer segments 6–7 mm. long, blade 10–12 mm. long, spreading, elliptic, shortly acute, pale lilac, with a darker blotch at the base;

inner segments 12–15 mm. long, 1–2 mm. broad, linear-lanceolate, acuminate, paler than the outer, perhaps white; filaments 2 mm. long, free almost to the base; style-arms 9 mm. long, 1·25 mm. broad, and slightly broader than the bluntly conical (not transverse) stigmas; lobes 2 mm. long, narrow, acute (white ?) (5) *Mossii.*

1. **H. elata** N.E. Br.—Standerton, Nov. *Rogers* 14799 type ! (Endemic).

2. **H. spicata** N.E. Br.—Of this plant I have not seen a specimen from the Transvaal, but the type of it, collected by Burchell without a number, is probably from Griqualand West; there is also a specimen in Hb. Moss (*Moss* 2895) collected at Kronstad in the Orange Free State, so that it will probably be found to occur in the Transvaal. The same or a very similar plant has also been collected in Basutoland (*Dieterlen* 186). There are no flowers to either of these specimens.

3. **H. simulans** N.E. Br.; *Morea simulans* Baker.—By a spruit of the Vaal River at Bloemhof *Nelson* 203 type ! (Endemic).

4. **H. propinqua** N.E. Br.—Zoutpansberg, *D.O.S.* 2462 type ! (Endemic). —This species is very similar to *H. simulans*, but differs by all the flower-clusters being sessile and more densely clustered; furthermore, it comes from a widely different locality. I do not doubt but that the flowers of the two species will be found to be quite distinct.

5. **H. Mossii** N.E. Br.—Geduld, Witwatersrand, in damp grassveld. Oct. *Moss* 15607 type ! 15852 ! (Endemic).—Flowers "pale lilac" *Moss.*

4. Homeria, Vent.

As this genus is usually supposed to be commemorative of Homer, it may be pointed out that it is derived from the Greek word *'omereo,* to meet together, because the filaments of the stamens are united into a sheath around the style.

The difference between this genus and *Morea* is very badly defined in books, but *Homeria* may easily be distinguished from *Morea* by the lobes at the end of each style-arm being small and subulate and narrower (instead of petaloid and as broad as or broader) than the transverse stigma at their base; the filaments of the stamens are also united for nearly all their length, but this character sometimes occurs also in *Morea*. The leaf is solitary in all known species.

Hitherto all the Transvaal specimens have been named *H. pallida* Baker, but the area contains at least four species and probably more, and I have not seen any specimen that I can with certainty identify as being *H. pallida* Baker. To this genus also belongs *Morea glauca* Wood and Evans,=**Homeria glauca,** N.E. Br., comb. nov.

Key to the Transvaal Species of Homeria.

a. Flower-clusters solitary at each node, or occasionally 2 at one of the nodes, *b.*

b. Stem (including flowers) 30–35 cm. high; flowers not dissectable, but with the outer segments (when dried) 18–20 mm. long and 5–6 mm. broad; "gamboge yellow" (teste *Burchell*) . . . . (1) *pallida.*

b. Stem (including flowers) 20–40 cm. high; outer perianth segments (of specimens in fluid) 15–17 mm. long and 4 mm. broad, linear-oblong, obtuse or shortly acute, truncate at the base, with a claw 1 mm. long, yellow, dotted with blackish at the base; inner segments similar, but rather smaller; united part of the filaments 4–5 mm. long; anthers 7 mm. long; style-arms 4 mm. long, yellow (2) *Mossii.*

a. Flower-clusters 2 or more at each node, *c.*

c. Stem (including flowers) in the only specimens seen, about 40 cm. high; leaf when flattened out 5–6 mm. broad; bracts 4–5 cm. long; outer perianth segments of dried flower 20–22 mm. long, 4–4·5 mm. broad, linear-oblong, obtuse; all the segments are yellow and very distinctly dotted with black at the base; stamens with the filaments united for 3–3·5 mm. and free above for 1 mm.; anthers 4·5–6·5 mm. long, shorter than or equalling the yellow style-arms (3) *Townsendiae.*

c. Stem (including flowers) 36–67 cm. high: leaf (when flattened out) 7–10 mm. broad; bracts 5–6 cm. long; outer perianth segments of dried flower 20–23 mm. long, 6–7 mm. broad, oblong, obtuse, yellow, without a trace of dots visible in the specimens seen, but one label states that they are "clear yellow with fine brown dots at the base"; united part of the filaments about 5 mm. and the free part 1 mm. long. (4) *pura.*

c. Stem (including flowers) 15–27 cm. high; leaf when flattened out 6 mm. broad; flower-clusters somewhat clustered together; flowers not dissectable (5) *humilis.*

1. **H. pallida** Baker. The type of this species was collected by Burchell (No. 2252/1) by the Mashowa River, near Old Takun in Bechuanaland. I include it here as all the Transvaal species have been wrongly determined as being it, but it may occur. Of the following species, *M. Mossii* is the most like it, but it differs by its smaller perianth segments.

The plant figured in Bulletin No. 6, 1922, of the Union Department of Agriculture as *Homeria pallida* is not that species, and I am unable to identify it with any specimen I have seen, because very few specimens have been dried so as to preserve the shape and colour of the segments of the flower. The figure referred to represents a plant with very acute flower-segments, light yellow, without spots at their base. If correctly represented this will be an undescribed species.

2. **H. Mossii** N.E. Br. sp. nov.—Geduld, Witwatersrand *Moss* 15606! type (Endemic).

3. **H. Townsendiae** N.E. Br. sp. nov.—Ermelo, *Townsend* in Hb. Moss 15810 type! (Endemic).

4. **H. pura** N.E. Br. sp. nov.—Orange Free State: Parys, damp grassveld *Young* in Hb. Moss 13494 type! Johannesburg: Eckstein Park, *Weeks* 206! Bankop near Ermelo *Burtt Davy* 1872! Marsh at Rustenberg,

Bell-John in Hb. Moss 11213 ! Pietersburg: Zoekmekaar *Rogers* 21497 ! Skinners Court, Pretoria *Burtt Davy* 607 !

5. **H. humilis** N.E. Br. sp. nov.—Pretoria District, *Maré* type !, Vereeniging, without name of collector !

Besides the specimens above enumerated I have seen a number of others, but as they have no flowers preserved in a recognisable condition it is not possible to determine them.

All the species of this genus are known by the name "Tulp" and are very poisonous to cattle.

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TRANSACTIONS

OF THE

ROYAL SOCIETY OF SOUTH AFRICA.

VOL. XVII.

MINUTES OF PROCEEDINGS.

Anniversary Meeting.

The Anniversary Meeting of the Society was held on Wednesday, March 17, 1926, at 7.45 p.m., in the Department of Physics, University of Cape Town.

The President, Dr. A. Ogg, was in the Chair.

The Report of the Hon. General Secretary was submitted and adopted.

The Report of the Hon. Treasurer was submitted and adopted.

The following were elected members of Council for the year 1926 :—

Sir Carruthers Beattie.	Dr. Annie Porter.
Mr. H. Spencer Jones.	Dr. B. F. J. Schönland.
Mr. F. E. Kanthack.	Dr. J. Smeath Thomas.
Mr. C. P. Lounsbury.	Dr. P. A. van der Byl.

Dr. P. A. Wagner.

Dr. A. Ogg was elected President.

Dr. L. Crawford, Hon. Treasurer.

Dr. W. A. Jolly, Hon. General Secretary.

The President delivered the Anniversary Address on the subject of "X-rays and Crystal Structure."

The President, after briefly explaining the work of Röntgen, who discovered X-rays in 1895, and the types of tubes in common use, carried out some experiments to show the improvements of high vacuum technique. An X-ray bulb was evacuated from atmospheric pressure to an X-ray vacuum by means of a mercury vapour pump backed by a Hyvac pump.

The nature of the radiations from the anticathode of an X-ray tube was explained as an " impulse " radiation and a " characteristic " radiation, the first being due to the stoppage of the swift-moving electrons or cathode rays, and the second due to the electrons of the anticathode.

Experiments with light showing a continuous spectrum with a characteristic spectrum superimposed were made to illustrate the radiations of an X-ray bulb as a continuous spectrum (impulse radiation) with a superimposed characteristic radiation.

Lantern slides of experimental results were then shown to demonstrate how the intensity of the radiation, the total radiation, the shortest wave length emitted, and the characteristic radiation depend on the voltage applied to the tube.

Experiments on the diffraction of light were then shown to illustrate the diffraction of X-rays by crystals and the method of calculating the grating space in a crystal was demonstrated.

The work of Moseley, Bragg, de Broglie, Siegbahn, and others on characteristic X-ray radiation was illustrated. The remarkable result of these experiments is that the spectra shift uniformly according to a very simple law as we pass from one element to the next in the periodic table. Moseley, who discovered the law, constructed a diagram which shows that there are still some elements undiscovered. Search for these missing elements by X-ray methods has led to the discovery of some of them as predicted.

The X-ray spectra of the elements in the wave-length from $0{\cdot}1\times10_{-8}$ cm. to 13×10^{-8} cm. may be divided into four groups called K, L, M, and N series, in accordance with the notation adopted by Barkla. Each group is divided up in a number of spectral lines. Between these groups there are regions which are quite devoid of lines. As we pass from element to element any given line is displaced towards the shorter wave length in passing from a lighter to a heavier element.

X-ray absorption was then dealt with, and it was shown that in order to excite characteristic radiation by X-rays the wave length of the incident X-rays must be shorter than the shortest wave length of the spectral group to be excited. The application of this principle in the construction of X-ray filters was illustrated.

The theory of the origin of X-rays rests on the modern concept of the atom which consists of a central positive nucleus with a planetary system of electrons round the nucleus in shells, usually spoken of as the K, L, M, and N rings. The changes which give rise to X-rays spectra take place in the inner region of the envelope of electrons. To excite K X-ray radiation an electron must be removed from the K ring outside the atom by the impact of cathode rays or by the absorption of energy from primary X-rays. The next step is the return of electrons to fill the vacancy. If the electron

falls in from the L ring it gives rise to a K_a radiation, and if from the M ring it gives rise to a $K\beta$ radiation. The L radiations are due to the falling in of electrons from the outer rings to the L ring.

There is excellent agreement between the experimental and theoretical results. The application of X-rays to the elucidation of crystal structure was then dealt with. Many lantern slides were shown to illustrate the principles of the methods used and the results as applied to inorganic and organic crystals.

Finally, the disintegration of the nucleus and the vast stores of energy locked up in the atomic nuclei were referred to. The unravelling of the structure of the nucleus is one of the great problems of the future. Rutherford calls it the greatest problem in Physics.

Ordinary Meeting.

An Ordinary Meeting was also held.

The President was in the Chair.

Business :—

The Minutes of the last Meeting were confirmed.

The following were nominated to Membership :—

Dr. A. D. R. Stammers, D.Sc., proposed by the Hon. General Secretary, seconded by Dr. L. Bosman ; and Mr. E. H. Croghan, M.A., F.I.C., proposed by Professor E. Newbery, seconded by the Hon. General Secretary.

Communications :—

" On some Strongylid Nematodes of the African Elephant," by H. O. Monnig.

The specimens were collected from elephants shot in the Addo Bush, Cape Province. Seven different species were found, of which four are new and are described in the paper, viz. *Murshidia brachyscelis ; Pteridopharynx brevicapsulatus ; Bunostomum brevispiculum*, and *Bunostomum haematum.*

" Three New Helminths," by H. O. Monnig.

Three new helminths are described (1) *Moniezia pallida* from the horse, (2) *Spirostrongylus australis* from the Red Kangaroo, and (3) *Cordophilus sagittus* from Cattle, Koodoo, and Bushbuck.

" Some Observations on certain Pathological Changes resulting from Inanition," by Arthur Dighton Stammers.

The author discusses the changes, especially in the adrenals, resulting from vitamin deficiencies in the diet.

" Glycolysis in Blood," by Arthur Dighton Stammers.

The paper contains a discussion of the fate of sugar in the blood after the removal of the latter from the body and an account of experiments on normal and diabetic blood.

"On the Presence of α-Hydroxy-acids in Blood," by ARTHUR DIGHTON STAMMERS.

The purpose of this note is to draw attention to the formation of saccharic and mucic acids by bacterial action in blood preserved in vitro and to the fact that if the latter be inhibited this oxidation process apparently does not occur.

"Variations in the Shells of *Isidora africana* (Krauss) and closely allied Species," by F. G. CAWSTON.

The difficulty is pointed out of dividing this genus into species by the appearance of the shells, and the radulae would appear to afford no better means of determining the species to which they belong.

"Hadamard's Approximation Theorem since 1900," by Sir THOMAS MUIR, F.R.S.

"A New Sundew—*Drosera regia* (Stephens)—from the Cape Province," by EDITH L. STEPHENS.

This species of *Drosera* requires a moist and comparatively cool atmosphere such as is provided by the south-east cloud at the height of 3000 feet, where it flourishes. Possibly this may be connected with the very copious secretion of the tentacles, which is so viscid as to snare even grasshoppers and small beetles. It belongs to a section (*Psycophila*) hitherto unrepresented in South Africa.

Its appearance is striking, a long peduncle, topped by a cluster of conspicuous pink flowers, being surrounded by linear leaves a foot or more in length. The fact that a plant of such remarkably distinctive aspect should have remained so long undiscovered close to Bains Kloof shows what a rich field is still offered for investigation by the flora of the South-west Cape.

WM. A. JOLLY,
Hon. General Secretary.

REPORT OF THE HON. GENERAL SECRETARY FOR 1925.

Eight Ordinary Meetings, the Annual Meeting, and the Anniversary Meeting were held during the year, and the undermentioned papers were read :—

1. "Impressions of the Bird Life of the Cape Peninsula," by E. L. GILL.

2. "On the Form of the Electrical Response of Muscle," by WILLIAM ADAM JOLLY.

3. "Notes on Solar Parallax," by H. SPENCER JONES (communicated by Dr. J. K. E. HALM).

4. "Some Observations on Aconitine," by LOUIS P. BOSMAN.

5. "Notes on the Habits and Life-histories of certain little-known Anura, with Descriptions of the Tadpoles," by J. H. POWER.

6. "Some Additions to the Knowledge of Procolophon, Lystrosaurus, Noteosuchus, and Cistecephalus," by F. VON HUENE (communicated by Dr. S. H. HAUGHTON).

7. "Report on a Collection of Crustacea from Portuguese East Africa," by K. H. BARNARD.

8. "New and Noteworthy S.A. Charophyta," by JAMES GROVES and EDITH L. STEPHENS.

9. "Contributions to our Knowledge of the Freshwater Algae of Africa. No. 6. Some Freshwater Algae from Stellenbosch," by W. HODGETTS (communicated by EDITH L. STEPHENS).

10. "Some Observations of the Radulae of Freshwater Mollusca," by F. G. CAWSTON.

11. "A Statistical Enquiry into the Population Problem in South Africa," by A. W. ROBERTS.

12. "A Note on Azotobacter in some South African Soils," by W. J. COPENHAGEN.

13. "Colour and Chemical Constitution, Part XX.—Some Residual Problems," by JAMES MOIR.

14. "Note on South African Ryncophora," by A. J. HESSE.

15. "The Molluscan Hosts of South African Trematoda," by F. G. CAWSTON.

16. "Note on the Arachnida of South-west Africa," by R. F. LAWRENCE.

17. "On some New Mollusca from Tertiary Beds in the West of the Cape Province," by S. H. HAUGHTON.

18. "On the Anatomy of some Shrubby Iridaceae," by R. S. ADAMSON.

19. "The Breeding Habits and Life-histories of some of the Transvaal Amphibia," by VINCENT A. WAGER.

20. "Cathode Ray Scattering," by B. F. J. SCHÖNLAND.

21. "Marriage and Mortality Rates of the Population of the Union of South Africa according to the conjugal condition of the Population," by C. W. KOPS.

22. "Colour and Chemical Constitution, Part XXI.—An Astronomical Orbit Theory of Colour, with special reference to the Dicyclic Azo Dyes," by JAMES MOIR.

23. "Note on Witchcraft in Europe: The Case of Anne Boleyn," by C. PIJPER.

24. (i) "The Preparation of Umbelliferone," by ERNEST GEORGE.
(ii) "Some Phthalein Analogues," by ERNEST GEORGE (communicated by Dr. JAMES MOIR).

25. "The Bryophyta of South Africa," by T. R. SIM.

26. "Note on the Decrease in Acidity during the Ripening of Grapes," by P. R. v. D. R. COPEMAN.

27. "An Extension of Ceva's Theorem to Polygons of any number of Sides," by ALEXANDER BROWN.

28. "The Hydrolytic Properties of certain Amino-Acids," by LOUIS PIERRE BOSMAN.

29. "Note on the South African Marine Mussel," by D. B. SWART.

30. (i) "On Instruments and Methods for Stereoscopic Surveying."
(ii) "The Optical Transformation of Projections and its Application to Mapping from Air Photographs."
(iii) "On some Conditions for the Accurate Vision of Stereoscopic Pictures," by H. G. FOURCADE.

Vol. XII, parts 3 and 4, and Vol. XIII, part 1, of the Society's Transactions have been issued during the year.

The undermentioned were elected Fellows of the Society in 1925 :—HENRY HAMILTON GREEN, D.Sc. (Glas.), F.C.S. ; HAROLD SPENCER JONES, M.A. (Cantab.), F.R.A.S. ; HENRY HOWARD PAINE, M.A. (Cantab.), B.Sc. (Lond. and Wales).

At the end of 1925 the number of Honorary Fellows was 1 ; Fellows 61 ; Members 161.

The deaths since the 1925 Anniversary Meeting of Dr. W. E. DE KORTE and Dr. J. J. VERSFELD, Members, are recorded with regret.

Messrs. G. M. CLARK, G. W. BAMPFYLDE DANIELL, S. H. HAYWARD, T. H. LE ROUX, R. E. MONTGOMERY, S. F. SILBERBAUER, G. H. STANLEY, R. B. THOMSON, and R. W. E. TUCKER are resigning from the end of 1925.

The names of three members are being struck off the List from the end of 1925.

The exchanges with the Library have been maintained during the year, and certain new exchanges have been arranged.

Two hundred and four volumes of periodicals have been bound during the year, and a further two hundred are about to be taken in hand.

The Society's reserve stock of Transactions, which had been left in charge of the Printers (Messrs. Adlard, London) since the beginning of the war, have now been brought out to this country and placed in store, in space kindly granted by the University of Cape Town.

Under the South African Museum Amendment Act (1925), it falls that one Trustee has to be appointed by the Council of the Royal Society of

South Africa, and in compliance with the Act the Council has nominated Professor W. A. Jolly, Hon. General Secretary, as its representative Trustee, for three years.

On July 7 the Society entertained to lunch the members of the scientific staff of the German Survey Ship "Meteor," which was calling at Cape Town, and subsequently members of the Society were entertained on board the "Meteor."

Wm. A. Jolly,
Hon. General Secretary.

TREASURER'S ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1925.

Revenue.

	£ s. d	£ s. d.
To Subscriptions for 1925 :—		
Subscriptions collected for 1923..	9 0 0	
,, ,, 1924..	34 16 0	
,, ,, 1925..	284 18 0	
,, ,, 1926..	1 13 6	
,, collected in advance for 1925	5 2 0	
Outstanding Subscriptions at December 31, 1925	48 1 0	
	383 10 6	
Less: Outstanding Subscriptions at December 31, 1924, £60, 14s; Subscriptions collected in 1925 for 1926, £1, 13s. 6d.	62 7 6	
		321 3 0
,, Entrance Fees		11 0 0
,, Government Grant, 1925–6		300 0 0
,, Interest received :—		
On Fixed Deposit, £500, at Standard Bank for one year at 4 per cent.	20 0 0	
On £408 New Union of South Africa 5 per cent. Stock	20 8 0	
On Money in Savings Bank Department of Standard Bank	17 8 5	
		57 16 5
,, Sale of Publications in 1925	37 13 5	
Plus: Amount due for Sale in 1925 ..	2 9 6	
	40 2 11	
Less: 1924 Accounts paid in 1925	2 16 9	
		37 6 2
		£727 5 7

Expenditure.

	£ s. d.	£ s. d.	£ s. d.
By Publications :—			
Cash Paid for Printing, etc., to Neill & Co.		683 13 3	
Less: Amount paid for 1924 Publications	241 10 9		
Less: Contribution towards Paper by C. W. Kops ..	15 0 0		
		256 10 9	
		427 2 6	
Less: Receipts for extra reprints of Papers ..	12 3 7		
Amount due for extra reprints in 1925 ..	4 10 2		
	16 13 9		
Amount received in 1925 for 1924 accounts ..	9 8 7		
		7 5 2	
			419 17 4
,, Compilation of International Catalogue of Scientific Papers			16 16 0
,, Clerical Assistance and Work in Library :			
Cash paid in 1925		53 10 0	
Amount due in 1925 to University of Cape Town towards salary of Assistant Librarian		12 0 0	
			65 10 0
,, Local Printing and Stationery			50 10 0
,, Postages and Petties			19 15 6
,, Binding: Accounts paid in 1925	£18 16 6		
Account due for 1925	15 8 0		
		34 4 6	
Less: 1924 account paid in 1925..		7 19 0	
			26 5 6
,, Bank Charges for Commissions, Ledger Fees, Fixed Deposit Stamps, etc.		3 7 10	
Less: Commissions paid by members ..		2 8 9	
			0 19 1
,, Hire of Rooms and Caretaker			6 6 0
,, Insurance :—			
Library, etc., in University Library ..		0 10 6	
Stock held by Adlard & Son and West Newman		1 13 10	
Storage Account paid in 1925		2 0 0	
Storage Account due for 1925		1 6 8	
Cost of bringing out Stock from England		29 8 5	
			34 19 5
,, Balance of cost of Lunch to Officers of Survey Ship "Meteor"			1 4 3
,, Profit in Year 1925			85 2 6
			£727 5 7

	£	s.	d.
,, Balance of cost of Lunch to Officers of Survey Ship "Meteor"	1	4	3
,, Profit in Year 1925	85	2	6
	£727	5	7

£727 5 7

ASSETS AND LIABILITIES AT DECEMBER 31, 1925.

Assets.*

		£	s.	d.
Money at Standard Bank on Fixed Deposit for one year at 4 per cent.		800	0	0
Money in Savings Bank Department of Standard Bank ..		265	18	6
Balance at Standard Bank as per Pass Book		37	3	6
Union of South Africa £408 5 per cent. Stock, 1929/39, reckoned at purchase price		400	0	0
Arrears of Subscriptions, as in Statement for 1924, £60, 14s.; less £43, 16s. paid in 1925 and £10, 17s. struck off as irrecoverable		6	1	0
Arrears of Subscriptions for 1925		42	0	0
Amount due for Sale of Publications		2	9	6
Amount due for extra reprints of Papers		4	10	2
		£1558	2	8

Liabilities.

		£	s.	d.
Subscriptions received in 1925 for 1926		1	13	6
Earmarked for Expense of Publishing, as a part of the Transactions, a Reproduction of a Bushman Painting (Council Minutes, May 12, 1915), a sum not exceeding		350	0	0
Sundry Creditors:—				
University of Cape Town towards salary of Assistant Librarian ..	£12 0 0			
Binding Account	15 8 0			
Storage of Stock	1 6 8			
		28	14	8
Excess of Assets over Liabilities:—				
Amount at December 31, 1924 ..	£1092 12 0			
Add Profit in year 1925	85 2 6			
		1177	14	6
		£1558	2	8

* Exclusive of value of Library and Publications of the Society held in Stock.

Entrance Fees and Life Subscriptions Fund.

	£	s.	d.
Amount of Fund at January 1, 1925	343	0	0
Entrance Fees received in 1925	11	0	0
	£354	0	0

	£	s.	d.
Amount of Fund at December 31, 1925	354	0	0
	£354	0	0

We hereby certify that we have examined the above accounts of Revenue and Expenditure and of Assets and Liabilities, with the Books, Vouchers, and other documents and securities relating thereto, and that in our opinion these accounts set forth a correct statement of the affairs of the Society.

ALEXANDER BROWN,
R. S. ADAMSON.

February 19, 1926.

An Ordinary Meeting of the Society was held on Wednesday, April 21, 1926, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business :—

The Minutes of the previous Meeting were confirmed.

The following were nominated to Membership :—Mr. J. F. V. Phillips, B.Sc. (Edin.), proposed by Professor P. A. v. d. Bijl, seconded by Professor B. de St. J. v. d. Riet ; Mr. R. C. McGaffin, M.Sc., A.I.C., proposed by Professor E. Newbery, seconded by the Hon. General Secretary ; and Dr. H. Zwarenstein, M.A., B.Sc., Ph.D., proposed by Dr. L. Bosman, seconded by the Hon. General Secretary.

The following were elected Members of the Society :—Dr. A. D. R. Stammers, D.Sc., and Mr. E. H. Croghan, M.A., F.I.C.

Dr. Marloth conveyed to the Society the thanks of the staff of the "Meteor" for the hospitality they have received.

Communications :—

"The Chorology of the S. African Heterosomata with some relative Problems," by C. von Bonde.

In this paper the Zoogeographical distribution of the S. African Flat-Fishes is dealt with. The paper is divided into Part I, dealing with Oecology or Environment of the species, and Part II, dealing with Chorology or their distribution in space. In Part I the various factors aiding distribution, such as ocean currents, etc., and those retarding dispersal, are examined. A comparison of the distribution of the Heterosomata with that of other marine faunas is tabulated, this showing a remarkable agreement in the ratio of their occurrence in deep-sea or in shallow water, the number of endemic species and the preponderance of East Coast species.

In Part II the localities of the various species are fully described and recorded on the sectional charts.

"The Structure of the Sulphates," by A. Ogg.

A model of the structure of Barytes ($BaSO_4$) based on the measurements of R. W. James and W. A. Wood (Proc. Roy. Soc., London, A, vol. 109) was exhibited, taking as atomic diameters Ba=4·20, S=2·05, O=1·30, Å. A structure of Anhydrite ($CaSO_4$) was also shown to explain the symmetry measurements of F. Rinne, H. Hentschel, and E. Schiebold (Zeitschrift f. Kristallographie, Heft 1, 164), in which the Ca and S atoms were placed on the reflection planes of the orthorhombic group V_{17} (Schonfliess notation). The SO_4 group is in the form of a tetrahedron.

The position of the SO_4 groups in the Alkaline Sulphates on symmetry planes were also indicated.

"An Occurrence of Diamonds near Port Nolloth," by W. A. HUMPHREY.

This occurrence is the first to be discovered on the Coastal Belt south of the Orange River.

The gravel is disposed in alternating layers of loose gravel and thin partings of hard conglomerate in which the constituents of the gravel are cemented together by a calcareous cement. This points to a seasonal deposition of gravel by a stream which was intermittent in its flow. The gravel shows signs of long-continued transport and the diamonds also show slight traces of wear.

The source of the diamonds is probably somewhere within the basin of the Kammas River, with which the watercourse containing the gravel was once connected.

The diamonds are very brilliant, white, and well crystallised, and resemble the stones found in the S.W. territory.

"The Changed Conditions of Namaqualand," by W. A. HUMPHREY.

An account is given of some of the river valleys of Little Bushmanland immediately south of the Orange River.

They have been formed by the action of streams of considerable volume, which cut their way through masses of mountains forming deeply dissected valleys and superb gorges during some far-distant pluvial period.

The upper courses of the shorter tributaries of the Orange in this neighbourhood have been gradually filled up with drift sand which has encroached from the north and obliterated the stream valleys altogether; in some cases mountain ranges are in the process of being buried from sight. The climate has changed from one with a comparatively heavy rainfall to its present semi-arid character.

The Kammas River, owing to the same causes, now no longer carries water to the sea, but is in course of filling up its own bed by its summer floods, which now spread the detritus from the Klipfontein Mountains in wide alluvial flats at twenty-nine miles, the river having filled up the lower portion of its course in its period of gradually diminishing activity.

This portion of Namaqualand represents an exceedingly old land surface in which valleys are gradually being filled up owing to a decrease in the humidity of the climate.

"Single Potential of the Copper Electrode," by R. C. McGAFFIN and E. NEWBERY.

Attention has been drawn to the very varied results obtained by different workers for the single potential of copper in solutions of its salts. It has been shown that one, at least, of the main factors producing this variation is the formation of an insoluble film of basic salt by the action of the electrolyte upon the metallic copper. Attempts have been made to obtain concordant and reliable values (*a*) by careful cleaning of the electrode and

measurement of the potential immediately after immersion, and (*b*) by retarding or, if possible, preventing the formation of the film either by rapid rotation of the electrode or by violent stirring of the electrolyte.

The values obtained by certain workers could only be reproduced when the electrodes were thoroughly coated with the insoluble salts.

WM. A. JOLLY,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, May 19, 1926, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. OGG, was in the Chair.

Business :—

The Minutes of the previous Meeting were approved.

The following were elected Members of the Society :—Mr. J. F. V. PHILLIPS, B.Sc. (Edin.) ; Mr. R. C. MCGAFFIN, M.Sc., A.I.C. ; and Dr. H. ZWARENSTEIN, M.A., B.Sc., Ph.D.

The following were nominated as Members :—Mr. D. B. SWART, M.A., proposed by Dr. C. VON BONDE, seconded by the Hon. General Secretary ; and Dr. FRANCIS DE VILLIERS, B.A., M.Sc., Ph.D., D.Sc., proposed by Dr. H. ZWARENSTEIN, seconded by the Hon. General Secretary.

In terms of Statutes, Chapters I., IV., the names of the candidates for Fellowship proposed in 1926 were read as follows :—ROBERT STEPHEN ADAMSON, M.A. ; WILLIAM CAMPBELL, M.B., Ch.B., B.Sc. ; AUGUSTA VERA DUTHIE ; BERNARD DE COLIGNY MARCHAND, B.A., D.Sc., and EDGAR NEWBERY, B.Sc., M.Sc., D.Sc., F.I.C., F.C.S.

It was announced that the Library of the Society has received from Dr. G. WÜST of the " Meteor " two reports on the work of the expedition, viz. " Die Atlantische Expedition auf dem Forschungs und Vermessungschiff 'Meteor' " (being collected papers by members of the expedition), and another Report under the same title by the late Dr. A. MERZ. These have been duly and gratefully acknowledged.

Communications :—

" An Early Embryo of the Blue Whale," by E. L. GILL, D.Sc.

The embryo was taken from a Blue Whale (*Balaenoptera sibbaldi*) at Saldanha Bay and presented to the South African Museum by Messrs. IRVIN and JOHNSON. It appears to be the earliest known embryo of a whalebone whale. It is at the stage reached by the human embryo at about the twenty-eighth day ; the two halves of the lower jaw have just met, but the

maxillary lobes are still far apart on the sides of the head. Though still in the main a generalised vertebrate embryo, it shows hints of cetacean characters in the small eye, large jaw elements, short neck, and reduced branchial arches, large genital papilla, and close segmentation. The fore-limb bud is large, but there is no visible trace of a hind limb. In size (about 6·5 mm.) it agrees closely with other embryos of the higher vertebrates (*e.g.* chick, rabbit, man) at the same stage of development.

"The Structure of the Plathander (*Xenopus laevis*)," Part I, by C. von Bonde and D. B. Swart.

It is the intention of the authors to give as detailed an account as possible of the structure of the "Plathander." A great deal of diversity of opinion about the structure exists, and it is hoped to elucidate matters considerably by means of a systematic description of *Xenopus*.

In the present paper a commencement is made with a description of part of the Morphology, viz. Oecology, Chorology, and Taxonomy, and the External Features. An attempt is made to fix the systematic position of the animal, which presents many primitive features, being related oecologically with the *Dipnoi* on the one hand and morphologically with the *Anuran* and *Urodelan* Amphibia on the other. Notable points with regard to the external features are (*a*) the abundance and properties of the secretion of the slime glands ; (*b*) the presence of definite groups of dermal sense organs ; (*c*) the presence of an eye tentacle in the adult ; (*d*) the cloacal lips in the female.

"Note on the Calcium Content of Blood," by L. Mirvish and L. P. Bosman.

The paper gives a preliminary account of a large number of determinations of the amount of calcium in the blood and the effect upon it of the injection of extracts of various body tissues, including ovarian and luteal extracts.

Wm. A. Jolly,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, June 16, 1926, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business :—

The Minutes of the last Meeting were confirmed.

The following were elected Members of the Society :—Mr. D. B. Swart, M.A., and Dr. François J. de Villiers, M.Sc., Ph.D., D.Sc.

The Hon. Librarian reported that the Society has received from Messrs. Longmans, Green & Co. a copy of Part I of a "Manual of Flowering Plants and Ferns of the Transvaal with Swaziland," by Dr. J. BURTT-DAVY. The gift has been acknowledged and the book deposited in the Society's Library.

Communications :—

"A Study of the Freshwater Isopodan and Amphipodan Crustacea of South Africa," by K. H. BARNARD.

Further evidence of the affinity of *Phreatoicus* and *Asellus* is given in the modification of the fourth peraeopod in the male, the shape of the first oostegite, and the development of dorsal processes in the embryo. A general account of the biology of *Phreatoicus capensis*, including a curious habit of aestivation, and certain tendencies to variation, is given. *Phreatoicus capensis* is shown to be extraordinarily closely allied to *P. australis*. These two forms are regarded as being the direct descendants of the ancestral stirps represented by the fossil species *wianamattensis*. A freshwater Isopod of the family *Jaeridae* is described, having affinities with the Australian genus *Heterias*. Several new species of "blind" Gammarids are described ; the eye of these "blind" species is histologically examined. The localised habitat of these "blind" species as contrasted with the wider distribution of the single black-eyed species is discussed. It is noted that *Phreatoicus capensis* is confined to old and mature valleys in the less highly tilted mountains and is not found at the present day outside the limits of the effective deposition of moisture from the clouds formed by the S.E. Trade winds. It is pointed out that the finding of a fossil species of *Phreatoicus* not only shows that the tribe was both austrogenic and palaegenic, but also puts out of court the theory of a migration of Northern Crustacea via the Andes into Australasia.

"The River System of S.W. Gordonia," by S. H. HAUGHTON.

In the last few miles of its course the Molopo River shows all the characters of rejuvenation impressed upon a mature stream—waterfalls, a winding deep gorge, and old river-gravels. This rejuvenation is due to the recession of the Aughrabies Falls past the mouth of the Molopo and the consequent cutting-back of the Molopo Falls to their present position. There is no permanent stream in the Molopo now.

The tributaries of the Orange to the west of the Molopo in Gordonia have arrived at a more mature stage, although they are deeply entrenched. Attention is drawn to the feeders of the Orange in Namaqualand, which similarly show steep gradients in their lower stretches only, the valleys suddenly falling from the plateau (which was already formed in Upper Cretaceous times) to the present level of the Orange, which runs at the bottom of a deep gorge. Possible causes of this rejuvenation are discussed.

The conclusion is reached that the cessation of erosive action in S.W. Gordonia must have been an event of geologically recent date.

"Measurements of the Electric Fields of Thunderstorms," by B. F. J. Schönland and J. Craib.

An observatory for the study of electrical meteorology was established on the farm Gardiol, near Somerset East, in January 1926. Measurements of the electric fields of thunderstorms have been made during the summer with a photographic recording apparatus similar to that designed by C. T. R. Wilson. An account was given of the apparatus and of measurements on 861 lightning flashes and some twenty storms, with some theoretical deductions.

Wm. A. Jolly,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, July 21, 1926, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business :—

The Minutes of the last Meeting were confirmed.

Communications :—

"The Action of Sulphur Chloride on Mercaptan—the Existence of Diethyl Tetrasulphide," by J. Smeath Thomas.

The author has previously shown that in the case of the alkali metals the maximum number of S atoms that can be introduced into the polysulphide molecule increases with increasing electro-positivity of the metal, that in the polysulphide series some members are of greater stability than others, and that only these more stable compounds are obtained by ordinary laboratory methods of preparation. In every case the disulphide is stable but the composition of the higher stable compound varies; the more electro-positive the metal the greater the number of S atoms in the molecule of the higher stable polysulphide.

An extension of the work to organic polysulphides led to a similar conclusion. Here, again, the disulphides are always stable and the higher stable polysulphide, in the case of the alkyl compounds, seems to be the pentasulphide.

Thus both sodium tetrasulphide and potassium pentasulphide on treatment with ethyl iodide yield diethyl pentasulphide mixed with a little disulphide.

In these circumstances the statement by Chakravarti that diethyl tetrasulphide is obtained by the action of sodium mercaptide on sulphur monochloride is of interest. An examination of the experimental details of his work shows that he failed to purify his product by distilling the disulphide at low pressure—a procedure which the author has found to be necessary.

On repeating Chakravarti's work with this precaution, a product apparently identical with diethyl pentasulphide (found C=22·09; H=4·56; S=73·50; $(C_2H_5)_2$. S_5 requires C=21·98; H=4·57; S=73·45).

The work is being continued.

"On the Rhythmical Functions of the Spinal Cord," by WILLIAM ADAM JOLLY.

The author discussed the oscillations which appear on the electromyograms in reflexes and the intraspinal delays, and pointed out the relation which subsists between the time intervals in the two phenomena.

"Colour and Chemical Constitution, Part XXII.—A Study of Methyl Derivatives of the Phenolphthaleins," by JAMES MOIR.

Nearly all the methyl derivations of phenolphthalein (ordinary and orthopara) have been examined. The effect of all substitutions on colour is additive, each item acting independently.

WM. A. JOLLY,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, August 18, 1926, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. OGG, was in the Chair.

Business :—

The Minutes of last Meeting were confirmed.

The following were nominated to Membership :—Professor B. J. RYRIE, M.B., Ch.B., proposed by Professor W. CAMPBELL, seconded by the Hon. General Secretary; and Dr. D. DOWIE DUNN, M.D., proposed by Dr. O. M. GERICKE, seconded by the Hon. General Secretary.

The President announced that the Society entertained the Captain and Scientific Members of the staff of the Royal Research Ship "Discovery" to lunch on 30th July.

Communications :—

"The Nature of the Co-enzyme of Lipase," by L. P. BOSMAN.

The lipase extract (from sheep's pancreas) is dialysed against distilled water and the lipolytic actions of the dialysate and the "inside" liquid on ethyl butyrate is studied. The inside liquid loses approximately 50 per

cent. of its hydrolytic power. The dialysate, while having no hydrolytic power, when coupled with the inside liquid, restores the lipolytic power of the original extract.

The dialysate was investigated and the so-called co-enzyme was found to be inorganic salts, corresponding with the inorganic activators as described by Mellanby and Woolley.

"Description of a New Species of Xenopus from the Cape Flats," by W. Rose and J. Hewitt.

The authors describe and figure a new species of Xenopus, occurring on the Cape Flats, distinct from *Xenopus laevis*, to which they give the name of *Xenopus gilli*. The new species differs from *X. laevis* in various ways, among which are the fact that tentacles are not apparent and that there is present in the mouth an organ which is either a posteriorly attached tongue or a deflated air-sac.

"Notes on the Habits and Life-histories of South African Anura, with Descriptions of the Tadpoles," by J. H. Power.

Observations made by the author at Lobatsi are described on *Phrynobatrachus natalensis*, *Rana fuscigula*, *Rana oxyrhynchus*, and *Bufo regularis*, and the Tadpoles of these species, and figures are given of the Tadpoles and of various anatomical features.

"The Vascular System of the Plagiostomi, with special reference to the Common Dogfish (*Squalus acutipinnis*, Regan)," by C. von Bonde.

The author has previously worked out the morphology of the vascular system of the South African Dogfish *S. acutipinnis*, and in this paper it is compared with the structure typical of the Plagiostomi in general and the following types in particular, viz. *Mustelus antarcticus*, *Scyllium canicula*, *Raia batis*, and *Chlamydoselachus anguineus*. The absence of vascular loops round the gill-arches, together with the absence of a precardiac extension of the dorsal aorta, presents an interesting feature. The arterial circulation of the cephalic region also shows a distinctive difference from the normal distribution of the carotid arteries in the Plagiostomi.

"The African Genera and Species of Restionaceae," by Neville S. Pillans.

This is a monograph of the African Restionaceae, based on the examination of about 4000 sheets of herbarium specimens contained in the Bolus Herbarium, Kirstenbosch, the Kew Herbarium, the British Museum, and many other collections.

"A New Method of Aerial Surveying," by H. G. Fourcade.

Wm. A. Jolly,
Hon. General Secretary.

Annual Meeting.

The Annual Meeting of the Society was held on Wednesday, September 29, 1926, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

The following candidates were elected Fellows of the Society :—Robert Stephen Adamson, M.A. ; William Campbell, M.B., Ch.B., B.Sc. ; Augusta Vera Duthie, M.A. ; Bernard de Coligny Marchand, B.A., D.Sc. ; Edgar Newbery, B.Sc., M.Sc., D.Sc., F.I.C., F.C.S.

Ordinary Meeting.

An Ordinary Meeting was held after the Annual Meeting.

The President was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

The following were elected to Membership of the Society :—Professor B. J. Ryrie, M.B., Ch.B., proposed by Professor W. Campbell, seconded by the Hon. General Secretary ; and Dr. D. Dowie Dunn, M.D., proposed by Dr. O. M. Gericke, seconded by the Hon. General Secretary.

The following were nominated for Membership :—Dr. T. R. Sim and Mr. T. J. Dry, B.A., proposed by the President, seconded by the Hon. General Secretary.

Communications :—

" The Bryophyta of South Africa," by T. R. Sim.

This communication constitutes an exhaustive fully illustrated monograph on the South African Bryophyta.

" Some Notes on South African Grasses," by E. Percy Phillips.

The author discussed the characters and distribution of the various S.A. grasses and the economic questions associated with them. The various effects of veld burning were described.

" Some Tadpoles from Griqualand West," by J. H. Power.

The early stages of *Cacosternum boettgeri* (Bouleng.), *Pyxicephalus dilalandi* (Tschudi), *Pyxicephalus adspersus* (Tschudi), and *Bufo vertebralis* (Smith) are described and figured.

Wm. A. Jolly,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, October 20, 1926, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. OGG, was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

Dr. T. R. SIM and Mr. T. J. DRY were elected to Membership of the Society.

The following were nominated for Membership :—Dr. F. W. BARKER and Dr. J. L. B. SMITH, proposed by Professor S. SCHÖNLAND, seconded by the Hon. General Secretary.

The following were received as Fellows :—Professor ROBERT STEPHEN ADAMSON, Professor WILLIAM CAMPBELL, Dr. BERNARD DE COLIGNY MARCHAND, and Dr. EDGAR NEWBERY.

Communications :—

"*Faurea M'Naughtonii* Phill. ('Terblanz'): A Note on its Ecology and Distribution," by JOHN PHILLIPS.

This stately forest tree (Proteaceae: sect. Persoonioideae) is of considerable interest on account of its peculiar regional and local distribution. In this communication certain ecological features of the tree are described and the possible reasons are discussed for its interesting distribution.

"Note on the Genus *Lobostemon* (Lehm)," by M. R. LEVYNS.

After a brief historical account of the genus the author proceeded to give reasons for abandoning the existing scheme of classification and for substituting a new one based on floral characters instead of the vegetative ones hitherto used. It was proposed to restrict the genus *Lobostemon* to those forms in which a definite scale or swelling is present on the corolla at the base of each stamen, and to constitute a new genus for those forms in which a scale or swelling is absent.

"Studies in the Growth of Grapes," by P. R. v. D. R. COPEMAN.

Equations have been developed for the growth changes in the acid, sugar, and soluble solid content of the juice and in the total solids in the berry for six different varieties of grapes analysed during three seasons. It has been shown that the growth of the grape berry may be divided into two distinct cycles. In the first cycle the soluble solids formed consist mainly of acid and protein. During the second cycle the changes in the soluble solids have been shown to be practically entirely due to the changes in the sugar and acid. Growth constants have been worked out for the factors studied, and it has been shown that these serve as a useful means of comparison between the different varieties for the different seasons.

"On a New Physaloptera from an Eagle and a Trichostrongyle from the

Cane Rat, with notes on *Polydelphis quadricornis* and the Genus *Spirostrongylus*," by H. O. Monnig.

Physaloptera rapacis n. sp. and *Heligmonella spira* n. gen., n. sp., are described and certain facts regarding *Polydelphis quadricornis* and the genus *Spirostrongylus* are discussed.

"Bushmen of Central Angola," by D. F. Bleek.

These Bushmen are Kung, speaking a language similar to the like-named inhabitants of the S.W. Protectorate. A description of their appearance, dress, mode of living and customs, shows them to be much influenced by the surrounding Bantu tribes, on whom they are becoming more and more dependent. Their religious beliefs are akin to those of other Bushmen, save for an acquired fetish worship. The absorption of the tribe by the Bantu races is predicted.

Wm. A. Jolly,
Hon. General Secretary.

Anniversary Meeting.

The Anniversary Meeting of the Society was held on Wednesday, March 16, 1927, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

The Report of the Honorary General Secretary was submitted and adopted.

The Report of the Honorary Treasurer was submitted and adopted.

The following were elected Members of Council for the year 1927 :—

Dr. H. B. Fantham. Dr. H. Spencer Jones.
Dr. H. H. Green. Mr. F. E. Kanthack.
Dr. J. W. C. Gunn. Mr. C. P. Lounsbury.
Dr. S. H. Haughton. Dr. B. F. J. Schönland.
Dr. B. de St. J. v. d. Riet.

Dr. A. Ogg was elected President.
Dr. L. Crawford, Honorary Treasurer.
Dr. W. A. Jolly, Honorary General Secretary.

The President referred to the Society's loss by death of two Fellows during 1926, and spoke as follows :—

William Arthur Caldecott, D.Sc. (Cape of Good Hope), although descended from one of the 1820 settlers, was born at Malta in 1869. His father

was the Rev. William Shaw Caldecott, a minister of the Wesleyan Methodist Church. Dr. CALDECOTT was brought to South Africa when he was seven years of age. He received his early education at the Grahamstown Public School and afterwards at the South African College. In 1889 he obtained the degree of B.A. of the University of the Cape of Good Hope with honours in Mathematics and Natural Science, his principal subject being Chemistry. He then went to the Rand, where the gold industry was in its infancy. He had thus the good fortune to be on the spot when the famous controversy arose between the amalgamation, the chlorination, and the cyanide processes of gold extraction. In 1890 the first working test of the cyanide process was made, and Dr. CALDECOTT devised a radical improvement in the application of that process. This begun his long and intimate association with the steady progress in the metallurgical history of South Africa, which qualified him so thoroughly for the task of editing—conjointly with others—a large volume on the South African gold industry, published a few years ago. After spending some years at Barberton and Pilgrims Rest and carrying out reseach in the works of the Rand Ore Reduction Company, he widened his experience by going to Rhodesia. He subsequently visited Mexico and the United States.

In 1908 Dr. CALDECOTT was elected a Foundation Fellow of the Royal Society of South Africa. He was elected a Member of the Council of the Royal Society in 1924 and in 1925.

In 1909 the University of the Cape of Good Hope conferred on him the degree of D.Sc. in recognition of his work on the Chemistry of the banket-ore treatment.

Dr. CALDECOTT was an Associate of the Institute of Civil Engineers, a Member of the Institute of Mining and Metallurgy, a Fellow of the Chemical Society of London, and at one time President of the Chemical Metallurgical and Mining Society of South Africa. For many years he was consulting Metallurgist to the Consolidated Gold Fields of South Africa. He was a Member of the Government Board of Industry and Science. Later, he was appointed Technical Adviser to the Industries Section of the Department of Mines and Industries. He retired to his farm in the Sundays River Valley, where he died in 1926.

Dr. CALDECOTT's life and work were closely associated with the industrial development of South Africa, in which he played an important part.

JOHN DOW FISHER GILCHRIST, M.A., D.Sc. (Edin.), Ph.D. (Zürich), was born at Anstruther, Scotland, in 1866. He was educated at Madras College, St. Andrews, St. Andrews and Edinburgh Universities. He obtained the M.A. and B.Sc. degrees of Edinburgh Universities after a distinguished career. After further study at Munich, Zürich, and Edinburgh Universities he obtained the Ph.D. (Zürich) and D.Sc. (Edinburgh).

In 1895 he was nominated by Edinburgh University to an 1851 Exhibition Science Research Scholarship. During the tenure of that Scholarship he carried on at Edinburgh University and various Fishery Stations researches on Food Fisheries.

In 1896 he was appointed Marine Biologist to the Government of the Cape of Good Hope, and subsequently became the Cape Government Biologist.

In 1905 he was appointed Professor of Zoology at the South African College, and later, Director of the Fisheries Survey for the Union Government, and Fish Adviser to the Cape Provincial Administration.

On arrival in South Africa in 1896 Dr. GILCHRIST became closely associated with the South African Philosophical Society. He was a member of the Council of that Society continuously from 1898 to 1903. He was President of the Society in 1904 and in 1905, Vice-President in 1906, and Treasurer in 1907.

When the Royal Society of South Africa was founded in 1908 he was elected a Foundation Fellow, and was a Member of the Council 1908, 1909, and 1910. He was elected President in 1918 and remained President until 1922.

He was President of the S.A. Association for the Advancement of Science in 1923. He was a corresponding member of the Zoological Society of London and a Fellow of the Linnean Society.

Dr. GILCHRIST published a large number of original and scientific papers chiefly on Marine Biology. These papers are to be found in "Marine Investigations," "The Annals of the South African Museum," "The Transactions of the South African Philosophical Society," "The Transactions of the Royal Society of South Africa," and "Marine Biological Reports."

In 1907 he published "South African Zoology," and in 1922, along with Dr. C. VON BONDE, "Practical Zoology for Medical and Junior Students." He was the discoverer of the Cape Agulhas fishing-grounds.

In 1926, owing to failing health, Dr. GILCHRIST retired from the Chair of Zoology at Cape Town University and went to Europe in search of health. He returned to South Africa again in July 1926, but died soon afterwards.

Dr. GILCHRIST has left behind a record of scientific work which is of great value to South Africa and to Biological Science.

Ordinary Meeting.

An Ordinary Meeting was held after the Anniversary Meeting.

The President was in the Chair.

Business :—

Minutes of the last Meeting were confirmed.

The following were nominated to Membership of the Society :—Dr. C. G. S. de Villiers, proposed by Professor P. A. van der Bijl, seconded by Professor B. de St. J. van der Riet ; Mr. Gilbert Henry Cock, B.Sc., Dip.Ag.Sc., proposed by Mr. A. H. Wallis, seconded by the Hon. Treasurer ; Dr. T. T. Barnard, M.A., Ph.D., proposed by Dr. L. Crawford, seconded by the Hon. General Secretary ; Mr. A. J. H. Goodwin, M.A., F.R.A.I., proposed by Dr. S. H. Haughton, seconded by Miss M. Wilman ; Dr. Marie G. Brandwijk, Phil.Doct., proposed by Dr. J. M. Watt, seconded by Dr. J. W. C. Gunn ; Dr. Lennox Gordon, proposed by Dr. M. R. Drennan, seconded by the Hon. General Secretary ; and Mr. T. Schrire, M.A., proposed by Dr. Louis P. Bosman, seconded by Dr. H. Zwarenstein.

Communications :—

"On *Xysmalobium undulatum*—A Chemical and Pharmacodynamical Study of ' Chonga ' (Bitter-wortel)," by J. M. Watt and Marie G. Brandwijk.

The drug is used in South Africa as an intestinal and uterine sedative. Among pharmacological actions determined are rise of blood pressure on intravenous injection, contraction of the uterus and intestine, and diuresis.

"The Comparative Anatomy of the Breast-shoulder Apparatus of the Three Aglossal Anuran Genera Xenopus, Pipa, and Hymenochirus," by C. G. S. de Villiers.

Full descriptions and figures of the anatomical characters are given. The author considers that Xenopus and the Hymenochirus group will prove to be more closely allied with each other than with Pipa, but, in the absence of any developmental material of Hymenochirus, the mutual relationships of the Ethiopian Aglossa remain a matter of pure speculation.

"Description of Three New Species of Anoplura from South African Mammals," by G. A. H. Bedford (communicated by Sir Arnold Theiler).

The new species are figured and described under the names of *Linognathus taurotragus* from eland, *Linognathus gnu* from black wildebeest or gnu, and *Linognathus ferrisi* from blue wildebeest named after Professor G. F. Ferris.

"Note on Hyperorthogonants," by Sir Thomas Muir.

Sylvester's suggested generalisation of the original conception of an orthogonant, although neglected for a generation, has, since Hadamard

recalled it to notice in 1893, received considerable attention ; and its properties are now readily ascertainable by the student. The same does not hold in regard to a second generalisation (the hyperorthogonant), which is of quite a different type and which not improbably may prove the more important of the two. Hence the present Note. So far as the author has been able to learn, use was first made of a hyperorthogonant in a paper by PETRINI in 1901.

Gifts to the Library of the 2nd Report of the German Atlantic "Meteor" Expedition by Dr. G. WÜST, and of a paper entitled "The use of a Discharged Tube for the Transmission of Speech," by Dr. C. W. VAN DER MERWE, were announced by the Hon. Librarian.

WM. A. JOLLY,
Hon. General Secretary.

REPORT OF THE HON. GENERAL SECRETARY FOR 1926.

Eight Ordinary Meetings, the Annual Meeting, and the Anniversary Meeting were held during the year, and the undermentioned papers were read :—

1. "On some Strongylid Nematodes of the African Elephant," by H. O. MONNIG.
2. "Three New Helminths," by H. O. MONNIG.
3. "Some Observations on certain Pathological Changes resulting from Inanition," by ARTHUR DIGHTON STAMMERS.
4. "Glycolysis in Blood," by ARTHUR DIGHTON STAMMERS.
5. "On the Presence of a-Hydroxy-Acids in Blood," by ARTHUR DIGHTON STAMMERS.
6. "Variations in the Shells of *Isidora africana* (Krauss) and closely Allied Species," by F. G. CAWSTON.
7. "Hadamard's Approximation Theorem since 1900," by Sir THOMAS MUIR.
8. "A New Sundew, *Drosera regia* (Stephens), from the Cape Province," by EDITH L. STEPHENS.
9. "The Chorology of the S. African Heterosomata, with some relative Problems," by C. VON BONDE.
10. "The Structure of the Sulphates," by A. OGG.
11. "An Occurrence of Diamonds near Port Nolloth," by W. A. HUMPHREY.
12. "The Changed Conditions of Namaqualand," by W. A. HUMPHREY.
13. "Single Potential of the Copper Electrode," by R. C. MCGAFFIN and E. NEWBERY.

14. " An Early Embryo of the Blue Whale," by E. L. GILL.

15. " The Structure of the Plathander (*Xenopus lævis*), Part I," by C. VON BONDE and D. B. SWART.

16. " Note on the Calcium Content of Blood," by L. MIRVISH and L. P. BOSMAN.

17. " A Study of the Freshwater Isopodan and Amphipodan Crustacea of South Africa," by K. H. BARNARD.

18. " The River System of S.W. Gordonia," by S. H. HAUGHTON.

19. " Measurements of the Electric Fields of Thunderstorms," by B. F. J. SCHÖNLAND and J. CRAIB.

20. " The Action of Sulphur Chloride on Mercaptan—the Existence of Diethyl Tetrasulphide," by J. SMEATH THOMAS.

21. " On the Rhythmical Functions of the Spinal Cord," by WILLIAM ADAM JOLLY.

22. " Colour and Chemical Constitution, Part XXII—A Study of Methyl Derivatives of the Phenolphthaleins," by JAMES MOIR.

23. " The Nature of the Co-enzyme of Lipase," by L. P. BOSMAN.

24. " Description of a New Species of Xenopus from the Cape Flats," by W. ROSE and J. HEWITT.

25. " Notes on the Habits and Life-histories of South African Anura, with Descriptions of the Tadpoles," by J. H. POWER.

26. " The Vascular System of the Plagiostomi, with special reference to the Common Dogfish (*Squalus acutipinnis*, Regan)," by C. VON BONDE.

27. " The African Genera and Species of Restionaceae," by NEVILLE S. PILLANS.

28. " A New Method of Aerial Surveying," by H. G. FOURCADE.

29. " The Bryophyta of South Africa," by T. R. SIM.

30. " Some Notes on South African Grasses," by E. PERCY PHILLIPS.

31. " Some Tadpoles from Griqualand West," by J. H. POWER.

32. " *Faurea M'Naughtonii* Phill. (' Terblanz ')—A Note on its Ecology and Distribution," by JOHN PHILLIPS.

33. " Note on the Genus *Lobostemon* (Lehm)," by M. R. LEVYNS.

34. " Studies in the Growth of Grapes," by P. R. v. D. R. COPEMAN.

35. " On a New Physaloptera from an Eagle and a Trichostrongyle from the Cane Rat, with Notes on *Polydelphis quadricornis* and the Genus *Spirostrongylus*," by H. O. MONNIG.

36. " Bushmen of Central Angola," by D. F. BLEEK.

Vol. XIII, parts 2, 3, and 4, Vol. XIV, part 1, and Vol. XV of the Society's Transactions have been issued during the year.

The undermentioned were elected Fellows of the Society in 1926 :— ROBERT STEPHEN ADAMSON, M.A. ; WILLIAM CAMPBELL, M.B., Ch.B., B.Sc.;

AUGUSTA VERA DUTHIE, M.A.; BERNARD DE COLIGNY MARCHAND, B.A., D.Sc.; EDGAR NEWBERY, B.Sc., M.Sc., D.Sc., F.I.C., F.C.S.

At the end of 1926 the number of Honorary Fellows was 1, Fellows 63, Members 152.

The deaths, since the 1926 Anniversary Meeting, of Dr. W. A. CALDECOTT and Dr. J. D. F. GILCHRIST, Fellows; Mr. P. J. DU TOIT and Dr. A. REITH FRASER, Members, are recorded with regret.

During the year one Fellow and two Members resigned.

The name of one member is being struck off the list from the end of 1926.

The exchanges with the Library have been maintained during the year, and certain new exchanges have been arranged.

Two hundred and ten volumes of periodicals have been bound during the year, and a further consignment is in the hands of the binder.

On July 30 the Society entertained to lunch the Captain and Scientific Staff of the Royal Research Ship "Discovery" en route to the Antarctic regions.

On September 21 the Society joined with the Botanical Society of South Africa in entertaining to lunch Professor C. SCHRÖTER, the distinguished botanist of Zürich, at present on a visit to South Africa.

WM. A. JOLLY,
Hon. General Secretary.

TREASURER'S ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1926.

Revenue.

	£ s. d.	£ s. d.
To Subscriptions for 1926 :—		
Subscriptions collected for 1924	5 0 0	
,, ,, ,, 1925	26 0 0	
,, ,, ,, 1926	268 10 6	
,, ,, ,, 1927	4 10 0	
,, ,, ,, 1928	1 0 0	
,, collected in advance for 1926	1 13 6	
Outstanding Subscriptions at December 31, 1926	64 17 0	
	371 11 0	
Less : Outstanding Subscriptions at December 31, 1925, £48, 1s. ; Subscriptions collected in 1926 for 1927 and 1928, £5, 10s.	53 11 0	
	318 0 0	
Plus : Subscriptions collected for 1922, 1923, 1924, 1925, formerly written off	8 0 0	
		326 0 0
,, Entrance Fees		10 0 0
,, Government Grant, 1926–7		300 0 0
,, Interest received :—		
On Fixed Deposit, £800, at Standard Bank for one year at 4 per cent.	32 0 0	
On £408 New Union of South Africa 5 per cent. Stock	20 8 0	
On Money in Savings Bank Department of Standard Bank	10 1 3	
		62 9 3
,, Sale of Publications in 1926	80 2 0	
Plus : Amount due for Sales in 1926 ..	7 7 4	
	87 9 4	
Less : 1925 account paid in 1926 £2 9 6		
1927 account paid in 1926 1 0 0	3 9 6	
		83 19 10
,, Stock held by Adlard & Son and West Newman : Refund on customs duty on bringing out Stock to South Africa		4 1 11
		£786 10 11

Expenditure.

	£ s. d.	£ s. d.	£ s. d.
By Publications :—			
Cash Paid for Printing, etc., to Neill & Co.		734 13 10	
Cost of Bank Drafts		4 0 9	
		738 14 7	
Less : Contribution by H. G. Fourcade towards cost of his Paper	20 0 0		
Part account for 1927 paid in 1926	200 0 0		
Grant by Research Grant Board for printing paper by T. R. Sim £260			
Less : Grant by Board for 1927 Printing 260	0 0 0	220 0 0	
		518 14 7	
Less : Receipts for extra reprints of Papers	6 18 10		
Amount due for extra reprints in 1926	4 16 9		
	11 15 7		
Less : Amount received in 1926 for 1925 accounts	4 10 2		
		7 5 5	
			511 9 2
,, Compilation of International Catalogue of Scientific Papers			16 16 0
,, Clerical Assistance and Work in Library ..		80 0 0	
Less : 1925 account paid in 1926 ..		12 0 0	
			68 0 0
,, Local Printing and Stationery			61 10 6
,, Postages and Petties			18 13 0
,, Binding : Accounts paid in 1926		37 19 0	
Less : 1925 account paid in 1926 ..		15 8 0	
			22 11 0
,, Bank Charges for Commissions, Ledger Fees, Fixed Deposit Stamps, etc. ..		3 6 10	
Less : Commissions paid by Members ..		2 2 5	
			1 4 5
,, Hire of Rooms and Caretaker			5 15 6
,, Insurance on Library in University Library			0 10 6
Stock held by Adlard & Son and West Newman :			
Storage account paid in 1926 ..		1 6 8	
Less : 1925 account paid in 1926		1 6 8	
			0 0 0
,, Wreath for funeral of Dr. J. D. F. Gilchrist			1 10 0
,, Profit in year 1926			78 10 10
			£786 10 11

ASSETS AND LIABILITIES AS AT DECEMBER 31, 1926.

Assets.*

	£	s.	d.
Money at Standard Bank on Fixed Deposit for one year at 4 per cent.	800	0	0
Money in Savings Bank Department of Standard Bank	355	19	9
Balance at Standard Bank as per Pass Book	39	14	6
Union of South Africa £408 5 per cent. Stock, 1929/39, reckoned at purchase price	400	0	0
Arrears of Subscriptions, as in Statement for 1925, £48, 1s.; less £31 paid off in 1926 and £6 struck off as irrecoverable	11	1	0
Arrears of Subscriptions for 1926	53	16	0
Amount due for Sale of Publications	7	7	4
Amount due for extra reprints of Papers	4	16	9
Amount paid in 1926 for Printing in 1927	200	0	0
	£1872	15	4

Liabilities.

				£	s.	d.
Subscriptions received in 1926 for 1927 and 1928				5	10	0
Received in 1926 for Sale of Publications in 1927				1	0	0
Received in 1926 for Printing in 1927				260	0	0
Earmarked for Expense of Publishing, as a part of the Transactions, a Reproduction of a Bushman Painting (Council Minutes, May 12, 1915), a sum not exceeding				350	0	0
Excess of Assets over Liabilities:—						
Amount at December 31, 1925	£1177	14	6			
Add Profit in year 1926	78	10	10			
				1256	5	4
				£1872	15	4

* Exclusive of value of Library and Publications of the Society held in Stock.

Entrance Fees and Life Subscriptions Fund.

	£	s.	d.
Amount of Fund at January 1, 1926	354	0	0
Entrance Fees received in 1926	10	0	0
	£364	0	0

	£	s.	d.
Amount of Fund at December 31, 1926	364	0	0
	£364	0	0

We hereby certify that we have examined the above accounts of Revenue and Expenditure, and of Assets and Liabilities, with the books, vouchers, and other documents and securities relating thereto, and that in our opinion these accounts set forth a correct statement of the affairs of the Society.

February 16, 1927.

ANDREW YOUNG,
E. LEONARD GILL.

An Ordinary Meeting of the Society was held on Wednesday, April 20, 1927, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

The following were elected to Membership of the Society :—Dr. F. W. Barker, Dr. J. L. B. Smith, Mr. Gilbert Henry Cock, B.Sc., Dip.Ag.Sc., Dr. T. T. Barnard, M.A., Ph.D., Mr. A. J. H. Goodwin, M.A., F.R.A.I. ; Dr. Marie G. Brandwijk, Phil.Doct. ; Dr. Lennox Gordon, M.B., Ch.B. ; and Mr. T. Schrire, M.A.

The following were nominated for Membership :—Professor Lancelot Hogben and Mr. Walter Rose, proposed by Professor E. Newbery, seconded by Dr. C. von Bonde ; and Mr. E. N. Grindley, M.Sc., proposed by Professor A. Ogg, seconded by Dr. B. F. J. Schönland.

Communications :—

" A Preliminary Note on the Rhenoster Bush (*Elytropappus rhinocerotis*) and the Germination of its Seed," by M. R. Levyns.

A short account is given of the distribution and characteristic features of two varieties of the Rhenoster bush. Descriptions are given of experiments in germination of the seed carried out in 1925 and 1926 under a variety of conditions, both natural and artificial. Reasons are given for the belief that under natural conditions the Rhenoster bush has no power of reproducing itself, and that its spread is largely due to man's influence, veld-burning being an important factor.

" On some Defensive Reflexes," by William Adam Jolly.

The author discussed the reflexes obtained in the hind limb of Xenopus on stimulation of one or both feet.

" Note on Overvoltage Problems," by E. Newbery.

Modern improvements in the methods of measuring overvoltage have shown that transfer resistance is a real quantity and therefore that the direct method of measuring overvoltage is incorrect. These improvements are mainly concerned with the reduction of the time interval between the interruption of the main current through the cell and the measurement of the single potential of the experimental electrode. In the original work this time interval was 0·02 second. Glasstone, with an improved type of commutator, reduced the interval to 0·002 second, whilst Sand has recently reduced it still further to 0·0001 second. Finally, the cathode ray oscillograph reduces it to 0·000,001 second.

The results obtained are all explainable on the hydride theory of overvoltage, but it appears that transfer resistance is in itself a complex quantity,

due chiefly to the resistance of a film of gas covering the electrode surface, but partly also to the presence of a partially exhausted layer of electrolyte surrounding the electrode.

"Some South African Crustacea," by K. H. Barnard.

Three species of Crustacea are known with certainty to be injurious to pier-timbers immersed in the sea in South Africa. Two are cosmopolitan: *Limnoria lignorum* (the Gribble) and *Chelura terebrans*. These are small species, not more than a quarter of an inch in length. The third species is *Sphaeroma walkeri*, which is common in India and seems to be spreading down the east coast into Natal. It reaches half an inch in length, and is capable of rolling itself into a ball. A Crustacean very similar to the last-mentioned species, *Parisocladus stimpsoni*, has been recorded from burrows in piles at the Simonstown docks, but it is as yet uncertain whether this species actually makes the burrows in which it was found.

Wm. A. Jolly,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, May 18, 1927, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. L. Crawford was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

The following were elected to Membership of the Society :—Professor Lancelot T. Hogben, Mr. Walter Rose, and Mr. E. N. Grindley.

The Hon. General Secretary announced that the following are candidates for Fellowship in 1927 :—Matthew Robertson Drennan, M.A., M.B., Ch.B., F.R.C.S.E.; Petrus Johann du Toit, B.A., Ph.D., Dr.Med.Vet.; H. G. Fourcade, D.Sc.; Thomas Robertson Sim, D.Sc., F.L.S., F.R.H.S.; Hendrik Johannes van der Bijl, M.A., Ph.D.

Communications :—

"A Method for the Study of Dissociation of Haemocyanin," by Lancelot T. Hogben.

An elaboration of the method proposed by Pantin and Hogben (1925) for studying the dissociation of the Oxyhaemocyanins is here described. The new method makes it possible to plot a five-point dissociation curve within a quarter of an hour with sera of Arthropods and Molluscs which can be kept indefinitely in the laboratory with prescribed precautions.

The general similarity in behaviour of haemocyanins and haemoglobins, the extreme simplicity of the method and the importance of haemoglobin justify the suggestion that the study of the haemocyanin system is a specially appropriate subject for laboratory work. Since a large yield can be obtained from such animals as Maia or Limulus, and since the blood of the animals, when filtered through muslin and shaken with chloroform, will keep indefinitely in the cold, no difficulty need arise in obtaining supplies through marine biological laboratories.

"The Theory of Hessians from 1883 to 1914," by Sir THOMAS MUIR.

"Note on some Features of part of the Orange River Valley," by S. H. HAUGHTON.

A brief account was given of the geographical features of the Orange River and its northern tributaries between the Haib River mouth and the Fish River mouth. The gorge-like nature of the valley and its independence of the geological structure of the country were discussed, and the unity of the Great Fish River and the lower part of the Orange was suggested.

"Archaeology of the Vaal River Gravels," by A. J. H. GOODWIN.

Ever since the discovery of diamonds in the Vaal River gravels, stone implements of a large almond-shaped type have been discovered and submitted to various museums, especially the M'Gregor Museum, Kimberley. Several writers, notably HAUGHTON, PÉRINGUEY, DU TOIT, and JOHNSON have written about these occurrences, but hitherto, except for JOHNSON'S work, no attempt at an archaeological study has been made.

It is the intention in this paper, in the first place, to draw the attention of science to the great volume of material which has been accumulating at Kimberley Museum and at other such museums for years past. These implements have hitherto received too little attention, and primarily the paper will deal with these. Secondly, an attempt will be made to place the implements into a time sequence, without attempting the impossible task of dating them. To do this it will first be necessary to correlate the work of the various writers on these gravels.

The gravels are situated at intervals along the Vaal River, sometimes at a considerable distance from the river, and at various levels above the river bed. The gravels are disjointed, and form various small groups. Each of these groups is a time sequence in itself. The lowest gravels are the latest, and are often in actual process of formation. The highest are probably the earliest. Unfortunately it is quite impossible to date these terraces with any degree of accuracy, but from the fossils discovered in the various terraces we must regard the earliest (highest) as being of what we may term "Lower Pleistocene" Age. The implements appear only in the lower terraces, and they must therefore be regarded as of later date than the

Lower Pleistocene, owing to the complete lack of such implements in the oldest terraces.

These implements are of a type similar to those described by PÉRINGUEY as of "Stellenbosch" type, but the technique approximates more closely to the culture described by Mr. C. VAN RIET LOWE, from Fauresmith, O.F.S. This may be due to the fact that the material used along the Vaal River is more similar in texture to that used at Fauresmith than it is to that used at Stellenbosch.

The Vaal River sites also give us a series of definite proofs that the smaller implements, popularly called "Bushman," are of far later date than the large almond-shaped types.

Unluckily, we have no evidence as to what type or types of men made these types of implements we find throughout the newer terraces. It would be a presumption to assume that either Rhodesian Man or Boskop Man was responsible.

While many fossils discovered have been presented to the various museums, yet on the other hand the vast mass of material found in the gravels has been discarded by the diggers, and much valuable evidence has thereby been lost. There are rumours that some of the fossils are apparently human remains, but no definite evidence is obtainable on this point, as the specimens have been reburied in the debris from the diggings.

"Studies in the Growth of Grapes, Part II—Relationship between Sugar and Acid in the Juice," by P. R. V. D. R. COPEMAN.

There is a very high degree of negative correlation between these two factors. The regression lines are not, however, linear, but the acid may be expressed in terms of the sugar by means of the equation $(y-a)^n = A/x - B$ where x and y are the sugar and acid respectively and a is the minimum acidity. This equation is only applicable during the period of decrease of acidity.

WM. A. JOLLY,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, June 15, 1927, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. OGG, was in the Chair.

Business :—

The Minutes of last Meeting were confirmed.

Communications :—

" The Exchange of Electricity between Thunderstorms and the Ground," by B. F. J. SCHÖNLAND.

Measurements were made in the summer of 1927 at Somerset East to determine the nature and magnitude of the exchange of electricity between thunderclouds and the earth. Such an exchange can take place in three ways : (*a*) by the direct passage of electricity in the form of a lightning discharge ; (*b*) by the precipitation of charged rain ; and (*c*) by point discharge from projections on trees, bushes, and grass, in the strong fields immediately below the cloud.

Seventeen active storms have been observed to pass over the station, all of which produced strong negative fields below them. This polarity is such as to give rise to a transfer of negative electricity to the earth by method (*a*) above, and an equivalent loss of positive electricity from the earth by method (*c*). Indirect observations on fifty-one more distant storms show that the great majority, if not all, of these were of similar polarity.

An estimate of the effect of (*a*) was arrived at from a study of the average amount of electricity discharged in a flash to earth and the average interval between such flashes. Taking these to be 20 coulombs and 120 seconds respectively, the effect is equivalent to ·17 coulombs per second, or a current of ·17 amperes.

The effect of point discharge (*c*) was estimated by setting up a typical thorn-tree (*Acacia Kaffra*) on sulphur insulators and determining the average value of the current leaving the tree when the thundercloud was overhead. This amounted to ·9 micro-amperes, averaged over an area of 50 sq. kms. beneath the cloud. The total number of such trees in this area was estimated at $2{\cdot}0 \times 10^6$, so that the upward discharge of electricity from them would amount to 1·8 amperes.

The effect of (*b*), the charge carried down by rain, was found to be quite negligible in comparison with (*a*) and (*c*).

Combining the above it was found that these clouds maintained a current of about 2 amperes between their bases and the ground in such a direction as to give a negative charge to the earth. Independent evidence was adduced to show that these clouds were capable of generating currents of the order of 3 amperes.

A discussion was given of the bearing of these results upon Wilson's theory of the replenishment of the earth's negative charge by means of thunderstorms.

" On the Herpetological Fauna of the Lobatsi-Linokana Area," by J. H. POWER.

The paper gives a description of the herpetological fauna collected in the three distinct habitats in the Lobatsi area, viz. :—(1) the hills, some of

which have very little vegetation, while others are covered with aloes and various trees and shrubs, are mostly dolomite and quartzite formations, and in some areas have precipitous sides; (2) the grassy valleys in which flourish various species of Acacia, some of them growing to a height of 40 feet or more. These trees grow in clumps, giving the valleys a park-like aspect. (3) The dams and pools, the edges of which, except in the case of rock-bound ones, are covered with reeds and sedges. These three habitats have each its particular fauna. Species of Lacertilia, Ophidia, Chelonia, and Anura are described and figured.

Wm. A. Jolly,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, July 20, 1927, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business :—

The Minutes of last Meeting were confirmed.

Communications :—

"The Symmetry and Crystalline Structure of the Crystals Potassium, Ammonium, Rhubidium, and Caesium Sulphate," by A. Ogg.

These crystals belong to the orthorhombic holohedry class, and may belong to any one of 28 symmetry groups, Q_h1 to Q_h28 (Hilton's notation). By considering the general nature of the X-ray spectra to be expected from each of these space groups and comparing these with the observed X-ray spectra it was concluded that this series of crystals belongs to the space group, Q_h16. The elements of symmetry in accord with the X-ray reflections are :

$$\begin{array}{lllll} \text{Reflection Planes} & (100)_{\frac{1}{4}}, & (100)_{\frac{3}{4}}, & & \\ \text{Glide Planes} \left\{ \begin{array}{l} \\ \\ \end{array} \right. & (010)_{\frac{1}{4}}, & (010)_{\frac{3}{4}}, & \text{Translation} & c/2 \\ & (001)_{\frac{1}{4}} & (001)_{\frac{3}{4}} & \text{Translation} & \dfrac{a+b}{2} \end{array}$$

with the corresponding dyad screw axes and centres of symmetry.

The number of asymmetric molecules required to produce the symmetry of the structure is eight. The unit cell was found to contain four molecules, hence the molecule must possess either a plane of symmetry or a centre of symmetry. The tetrahedral form for the SO_4 group was assumed as has

been found in other sulphates, so the molecule cannot possess a centre of symmetry. The S atoms therefore lie on the reflection planes with two O atoms on the plane and two equidistant from the plane on a line at right angles to the plane.

The proposed structure gives the distance between a S centre and an O centre as 1·5 Å, and the nearest approach of a K centre to an O centre as 2·7 Å. The distances between the metal centres and the oxygen centre in other members of the series are somewhat larger.

The structure gives an explanation of the twinning of these crystals and the formation of almost true hexagonal prisms.

"Studies in the Growth of Grapes, Part III. The Effect of Environment upon the Growth Constants," by P. R. v. d. R. Copeman.

The same type of equation, as used in a previous paper, was found to be applicable in the case of grapes grown in a different locality. It was found, however, that the values of the constants in the different equations were directly affected by changes in environment. It seems that plants are affected by environment to a greater extent than animals. The results showed that changes due to environmental conditions were greater than those due to seasonal conditions.

"The Behaviour of *Acacia melanoxylon*, R. Br. ('Tasmanian Blackwood') in the Knysna Forests: An Ecological Study," by John F. V. Phillips.

"Blackwood" acts detrimentally upon the regeneration of the more important forest species, and is a plant which might become commoner if forests containing its dormant seeds were to be distributed. Despite its value as a timber tree and its efficiency as a killer of weeds on open sites, it is not considered wise to plant the species in gaps in the main forests, but to confine its production to burnt and otherwise ruined patches and isolated forests of poor quality.

Wm. A. Jolly,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, August 17, 1927, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. Ogg, was in the Chair.

Business:—

The Minutes of last Meeting were confirmed.

Communications :—

"Some New Species of Curculionidae from South Africa and South-West Africa," by A. J. Hesse.

In this paper twenty-five new species are described, belonging to eight sub-families and thirteen genera.

They are { Cape : 17 n. species,
S.W. Africa : 5 n. species,
Transvaal and Natal : 2 n. species,
Rhodesia : 1 n. species.

The total number of *Hipporrhinus* species 146 has been increased to 152. The genus *Solenorrhinus*, which up to now was composed of only one species, has been enriched by two other new species, one of which is found on the Silver-leaf trees on Signal Hill.

Two of the described Curculionidae are found in such widely separated areas as Zululand and S.W. Africa and Transvaal and S.W. Africa.

"Studies in the Growth of Grapes, Part IV.: The Initial Changes in Acidity," by P. R. v. d. R. Copeman.

During the initial stages of growth of the berry the changes in acidity of the juice are found to be autocatalytic in character. At the moment of formation of the berry there is a definite concentration of acid in the juice. This must be the concentration of acid in the liquid which appears in the berry during the initial stages of formation of the berry.

"The Dinosaur Beds of Lake Nyasa," by F. Dixey, D.Sc., F.G.S. (communicated by Dr. S. H. Haughton).

This paper describes the distribution and lithology of a series of sediments occurring along the North-western shores of Lake Nyasa which have yielded a number of interesting Dinosaur remains which are allied to the better-known deposits of Tendaguru. The beds consist principally of a great thickness of friable sandstones, sandy marls, and clays. They lie unconformably on older rocks which are affected by post-Karroo faults, and are themselves faulted and overlain by more recent deposits of the Nyasa trough.

Their relation to the Dinosaur-bearing beds of Tanganyika Territory is also discussed.

"On some Reptilian Remains from the Dinosaur Beds of Lake Nyasa," by S. H. Haughton.

The fossils obtained by Dr. Dixey, although numerous, are fragmentary and scattered. It has been possible to identify two forms specifically ; and many other bones can definitely be assigned to the Sauropoda. The forms named are *Platycheloides nyasae* gen. et sp. n., the first recorded African Mesozoic Testudinate, and *Gigantosaurus dixeyi* sp. n., a Sauropod allied to

a form described from Tendaguru. These, and some other bones, are described and figured.

"On a Myosurus from South Africa, with some Notes on *Marsilia macrocarpa*," by D. THODAY and M. A. POCOCK.

The discovery is recorded of a species of Myosurus, a genus new to South Africa. It is identified provisionally, in the absence of material with ripe achenes, as *Myosurus minimus*.

WM. A. JOLLY,
Hon. General Secretary.

ANNUAL MEETING.

The Annual Meeting of the Society was held on Wednesday, September 28, 1927, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. OGG, was in the Chair.

The following candidates were elected Fellows of the Society :—MATTHEW ROBERTSON DRENNAN, M.A., M.B., Ch.B., F.R.C.S.E.; PETRUS JOHANN DU TOIT, B.A., Ph.D., Dr.Med.Vet.; HENRY GEORGES FOURCADE; THOMAS ROBERTSON SIM, D.Sc., F.L.S., F.R.H.S.; HENDRIK JOHANNES VAN DER BIJL, M.A., Ph.D.

ORDINARY MEETING.

An Ordinary Meeting was held after the Annual Meeting.

The President was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

The following were nominated for Membership :—ANTON GODFRED HOYER, F.R.S.A., proposed by Dr. F. G. CAWSTON, seconded by the Hon. General Secretary; and Dr. W. PUGH, B.Sc. (London), Ph.D. (Cape Town), proposed by Professor J. SMEATH THOMAS, seconded by the Hon. General Secretary.

Communications :—

"Studies in the Growth of Grapes," Part V., by P. R. v. D. R. COPEMAN.

It is shown that the relationship between the sugar and soluble solids in the juice of the grape is a linear function. The slope of the line is closely related to the growth yields of these two factors during the period of ripening. The variations of the constants for different varieties lie within narrow limits

and it is possible to obtain a general expression for the sugar in terms of the soluble solids, and this is practically independent of changes in locality and season. It is shown that it is possible to use the Balling degrees of the juice to estimate the amount of sugar per 100 c.c. of juice.

"The Dentition of a Bushman Tribe," by M. R. DRENNAN.

This paper contains an anthropometric survey of the teeth of a Bushman Tribe. The collection comprises the remains of fifty-three individuals reputed to be Bushmen. Comparative data from the dentition of the Kaffir and a few gorillas and baboons are also discussed.

"The Osteology of a Bushman Tribe," by D. SLOME, B.A. (communicated by Professor M. R. DRENNAN).

This work is an anthropological survey of the skeletons of a tribe of aborigines exhumed at Colesberg by the South African Museum, Cape Town.

Fifty-three skulls were available for study, and these were first of all separated into a group of forty-five relatively pure Bushman types, and the remainder of definitely mixed types. A number of these skulls were fragmentary and deformed, so that the Bushman types, which were suitable for study, numbered twenty-nine.

The limb bones and the sacrum were also studied.

The conclusion is arrived at that the larger group is composed of relatively pure Bushmen, more typically Bushman, especially as regards the smallness of their bones, than many other groups which have been described as Bushmen. Nevertheless, there appears to be a strain of what might be termed Hottentot blood in them, as evidenced by the narrowing of the skull and the apparent subnasal prognathism.

"Colour and Chemical Constitution, Part XXIII.: The Pigments of Flowers," by JAMES MOIR.

By making and spectroscoping a number of new synthetic derivations, the author has filled the gap between the anthocyanidines and their parent, flavylium chloride, and so enabled the change of shade to be followed completely, so that this apparently complex subject is placed on a single basis.

Some of the corresponding phenylquinolinium compounds have been also synthesised and examined, whereby the effect of replacing O by NH all over the compounds can be seen : the colour is lowered by about 20 per cent.

All the anthocyanidines, except the simplest, possess from three to five different shades, each according to the reaction of the solution: an attempt is made to explain this by analogy with other polychromatic dyes.

Tables are also given (*a*) showing the "heightening" effect on the colour of lengthening the molecule, and (*b*) the lowering effect of S, O, and NH when they replace CH : CH in the ring.

"Some Observations on the Production of Excitement Pallor in Reptiles," by LANCELOT HOGBEN and LOUIS MIRVISH.

The production of excitement pallor in chameleons is shown by spinal transection to be determined by a segmental mechanism. The possibility of evoking pallor by stimulation of the cord in isolated segments after the circulation has been cut off indicates that the pigmentary effector organs are under direct nervous control. It is unlikely that adrenal secretion plays any significant part in the determination of excitement pallor in chameleons.

"Note on a Rorqual buried on the Cape Flats," by E. L. GILL.

This note records the finding of the skeleton of a rorqual (*Balaenoptera* sp.) in surface deposits on the Cape Flats, near Maitland. The circumstances appear to furnish evidence for a comparatively recent rise of level of the Flats in relation to the sea.

"The Structure and Life-history of the South African Lagarosiphons," by VINCENT A. WAGER.

This investigation was undertaken with the idea of finding real specific differences, if any, between the South African species of Lagarosiphon, and to study some points in connection with the structure, morphology, physiology, and life-history of these and some other water plants.

WM. A. JOLLY,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, October 19, 1927, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. OGG, was in the Chair.

Business :—

The Minutes of the last Ordinary Meeting were confirmed.

The following were elected to Membership of the Society :—ANTON GOTFRED HOYER, F.R.S.A., and Dr. W. PUGH, B.Sc. (London), Ph.D. (Cape Town).

Dr. PETRONELLA VAN HEERDEN was nominated for Membership.

Professor M. R. DRENNAN, M.A., M.B., Ch.B., F.R.C.S.E., was admitted a Fellow of the Society.

The Council's recommendation for Officers and Council for 1928 is as follows :—

President, Dr. W. A. JOLLY ; Hon. Treasurer, Dr. L. CRAWFORD ; Hon. General Secretary, Dr. A. OGG.

Dr. R. S. Adamson, Dr. A. L. du Toit, Dr. H. B. Fantham, Dr. J. W. C. Gunn, Dr. S. H. Haughton, Dr. C. F. Juritz, Mr. C. M. Stewart, Dr. J. Smeath Thomas, and Dr. B. de St. J. v. d. Riet.

Discussion :—

A Discussion on "The Physical Characteristics of the Bushman" was opened by Professor M. R. Drennan.

Professor M. R. Drennan opened the discussion by giving a summary of four papers which had been written recently on the physical characters of the Bushman from material in the Anatomy Department of the University of Cape Town and in the South African Museum, Cape Town, kindly lent to the authors for this purpose by Dr. Leonard Gill, Director of the Museum.

(1) "The Curvature of the Bushman Calvarium," by D. Slome, B.A.

In this paper the characteristic curvature of the Bushman skull-cap is subjected to a very accurate form analysis by making dioptograph drawings of the sagittal arc of twenty-eight typical Bushman skulls. The arc is then subdivided into its frontal, parietal, and occipital components, and measurements are made of the various arcs, chords, and angles. Attention is drawn to the vertical forehead of the Bushman, the frontal angle being a few degrees higher than the corresponding angle in the European. This is in great contrast to the low simian slope of the forehead in other primitive races, such as the Australian aboriginal; and inasmuch as it is found in the foetal skull and in young individuals amongst the higher races, it is probably best interpreted as being one among the many infantile characters presented by the Bushman.

The measurements also bring out the flattening and lowness of the vault of the Bushman cranium.

A comparison is then instituted between the Bushman calvarium and that of the Apes, Pithecanthropus, Neanderthal man, and other more modern types, and an attempt is made to grade their evolutionary relationship by giving values to each of them in respect of the various characters compared. The order is as follows: European 91 per cent., Bushman 88 per cent., Tasmanian 84 per cent., Australian 78 per cent., Cromagnon 72 per cent., Galley Hill 68 per cent., Neanderthal 38 per cent., Pithecanthropus 17 per cent., and the Anthropoids 10 per cent., in respect of their cranial characters.

(2) "The Osteology of a Bushman Tribe," by D. Slome, B.A.

The author makes an anthropological survey in this paper of the skeletal remains of a tribe of aborigines, comprising fifty-three individuals, exhumed near Colesberg, C.P., by Mr. J. Drury, for the South African Museum. After separating out eight individuals of mixed and Bantu types, the remainder is found to constitute relatively pure representatives of the Bushman race.

In physical features the Hottentot is generally regarded as tending to leave the Bushman standards and to approximate in a definite degree towards the Bantu standards. In a few of the measurements this tribe leaves the Bushman " norm " in the Hottentot direction, but in the great majority of cases the measurements and indices coincide with what are generally taken as Bushman " norms," or even diverge in a more extreme Bushman direction. This is especially true in regard to the absolute size of the bones of this tribe, especially the pelvic and limb bones, which are small and delicate. The cranial capacity averages 1165 c.c. for the males and 1098 c.c. for the females, which is the lowest so far recorded for a Bushman group. The stature of the group is calculated to be about 5 feet for the males and 4 feet 9 inches for the females.

(3) " The Dentition of a Bushman Tribe," by M. R. DRENNAN.

In this paper the author makes an anthropometric survey of the dentition of the tribe dealt with in the previous paper, together with a preliminary examination of the teeth of uncivilised Bushmen, and a few Kaffirs, Gorillas, and Baboons. The results are set out in comparative tables, together with data taken from Campbell's monograph on the " Dentition of the Australian Aboriginal."

Various measurements and indices are devised to record the shape and size of the teeth, and the outstanding result is the small size of the Bushman teeth compared with those of other races. There is also found to be a greater degree of reduction in the size and in the number of cusps in the upper molars of the Bushman than in the lower molars. This is discussed in relation to the more edge-to-edge bite of the Bushman as compared with the usual overlap of the European bite.

The degree of attrition of the teeth is compared in the uncivilised and the civilised Bushman, and is found to be much less in the latter than in the former. This condition has lessened gradually in Europeans with the slower growth of civilisation, but it has occurred much more suddenly in the Bushman, in keeping with the more sudden impact of civilisation upon him.

The incidence of the various dental diseases is examined, and whilst the incidence of caries is much less than in modern races, the incidence of apical abscesses, due largely to the wearing away of the teeth and the exposure of the pulp, is relatively high, especially in the uncivilised Bushman.

(4) " The Pudendal Parts of the South African Bush Race," by J. DRURY, with M. R. DRENNAN.

This paper records notes taken by Mr. DRURY on the peculiar formation of the external genitals of the Bushwomen, known under the term " longinymph." All the Bushwomen and Hottentots who have been examined have had an elongation of their labia minora or nymphae. It was found

that in South-West Africa the Bushwomen practised concealment of these parts within the vagina.

Cape and Bechuanaland Bushwomen had labia of the "wattle" type of formation, whilst South-West African and Transvaal Bushwomen had labia of the "butterfly" type.

The author made notes on the size and shapes of the prominence of the gluteal region, known as steatopygia. This is discussed as being possibly due to sexual selection, and, on the ground of its advantage as a reserve of food in time of famine, it may have been an important factor in natural selection. The character must have been specially valuable to the female, who had to carry and nurse her children in times of famine, so that it is easy to see how it may have been perpetuated in them. An endocrine mechanism may be involved in acquiring these characters.

Reference is also made to the semi-erect position of the penis and to the partially undescended testes in the male. These and the characters of the female parts are probably infantile. None of these races practise circumcision.

Communications :—

"*Olea laurifolia* Lam. ('Ironwood'): An Introduction to its Ecology," by J. F. V. PHILLIPS.

This is a highly important tree ecologically, sylviculturally, and economically. Despite its slowness of growth and the various disabilities to which it is subject, the species is fully capable of holding its ground in the Knysna forests and even of increasing its frequency if not kept in check. The value of the timber and the steady demand for this, combined with the importance of the ecological rôle of the species, indicate that it is well worth the sylvicultural attention the Forest Department of the Union of S.A. is giving it.

"A New Method of Aerial Surveying," Second Paper, by H. G. FOURCADE.

In continuation of the previous paper, the adjustment of an aerial traverse to terminal conditions is developed. An instrumental method of transferring, without computations, the vertical point from plate to plate is described, and a simple procedure for determining the directions of successive air bases worked out. It is also shown that the ground control may be limited to single points at the ends of traverses, instead of the clusters of three formerly thought necessary for fixing the positions of the terminal pairs of plates. These simplifications result in a complete method in which ground control and computations have been reduced to a minimum.

"The Principal Point and Principal Distance in Photogrammetry," by H. G. FOURCADE.

The principal distance gives the angular scale of photographs and, in

consequence, is a fundamental constant of the photogrammetric camera. The principal point, being the origin from which plate measures must proceed, is equally important. Former methods for determining these constants lacked precision because they depended on linear measurements of a central projection made upon a commercial plate, which usually is by no means plane, and either ignored distortion or treated it as an accidental error. It is shown how these sources of error may be avoided and a rigorous solution obtained without adding complication.

"Studies in the Growth of Grapes, Part VI.: The Acid-Sugar Ratio," by P. R. v. d. R. Copeman.

It has been found that an expression of the form $y=\frac{b}{x}-\frac{c}{x^2}-a$ may be used to express the acid "y" in terms of the sugar "x." The constants are affected to a greater extent by changes in locality than by seasonal changes. If "r" be the ratio of acid-sugar, then $rx=\frac{b}{x}-\frac{c}{x^2}-a$, and therefore the ratio may be calculated from the sugar content of the juice. Figures have been given which show that the grapes may be considered ripe when the juice has a Balling reading of 16–17° according to the variety.

Wm. A. Jolly,
Hon. General Secretary.